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GEOLOGICAL SURVEY OF THE UNITED KINGDOM

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MEMOIRS OF THE GEOLOGICAL SURVEY
OF THE
UNITED KINGDOM.

THE
CRETACEOUS ROCKS
OF
BRITAIN.

VOL. III.—THE UPPER CHALK OF ENGLAND.

BY

A. J. JUKES-BROWNE, B.A., F.G.S.

WITH CONTRIBUTIONS BY

WILLIAM HILL, F.G.S.

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PREFACE.

THE present volume deals principally with the stratigraphical and palæontological characteristics of the Upper Chalk. It forms the third and concluding volume of Mr. Jukes-Browne's monographic work on the Upper Cretaceous Rocks of England. After giving a general account of the Upper Chalk, the author describes the stratigraphical features of this stage as it is developed in different portions of the country, and the several chapters of this part of the work have been made to coincide as nearly as possible with county divisions, for convenience of reference. On this as on previous occasions the Geological Survey has received great assistance from Mr. William Hill, whose detailed investigations on the microscopical structure and composition of the different zones of the Upper Chalk are published in the present volume. The concluding chapters deal with the physical features, economic products and hydrographic characteristics of the Chalk formation as a whole.

A work of this kind is necessarily based to a great extent on the labours of previous observers, and a general bibliography relating to the Upper Cretaceous Rocks of England, therefore, finds a fitting place at the end of the present volume, which is the last of the series.

In this preface it is unnecessary to refer to the earlier workers, who have laid the foundation of our knowledge of the Upper Chalk, but it is impossible to avoid all reference to the brilliant researches of Dr. Arthur Rowe, whose papers have been published during the preparation of this volume. The result of these researches, which have greatly extended our knowledge of the White Chalk of England, have been incorporated as far as possible in the present volume, but the original papers are so concise and so admirably illustrated that they must be consulted by all future workers on this formation.

The preparation and revision of the General List of fossils found in the Chalk has occupied a great deal of time, and it is hoped that the information thus brought together as regards the zonal range and the geographical distribution of the fossils will be appreciated by students of the Cretaceous fauna.

The fossils collected by the Survey have been named by Mr. E. T. Newton with the assistance of Mr. H. A. Allen and Dr. F. L. Kitchin, and Mr. Newton has revised the synonymy in the General List and in the other lists throughout the volume.

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The author is indebted to Mr. F. Chapman (now of Melbourne) for examining and naming the Foraminifera and Ostracoda which were isolated by Mr. Hill, and he likewise acknowledges most gratefully the assistance he has received from Dr. H. P. Blackmore, Mr. R. M. Brydone, Mr. A. Burnet (of Leeds), Mr. Ch. Griffith (of Winchester), Mr G. W. Lamplugh, Mr. E. Meyrick (of Marlborough College), Dr. A. W. Rowe, Mr. J. Scanes, Mr. J. W. Stather (of Hull), Mr. W. Whitaker, Mr. H. J. Osborne White, and Mr. H. Woods.

J. J. H. TEALL,
Director.

Geological Survey Office,
28 *Jermyn Street, London.*
28th November, 1903.

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[*Note.*—This Plate follows on from Plate VIII. in Vol. II. of this Memoir.]

THE UPPER CHALK OF ENGLAND.

CHAPTER I.

GENERAL ACCOUNT OF THE UPPER CHALK.

A general account of the Chalk as a whole, and of its division into Lower, Middle and Upper Chalk, has been given in Volume II. of this series of memoirs. The Lower and Middle stages were described in that volume, and the present one will deal mainly with the Upper Chalk.

Since the description of the Chalk Rock by Mr. Whitaker in 1859 (see Vol. II. pp. 5 and 359), the Upper Chalk has generally been defined as all that part of the Chalk which overlies that rock wherever it can be identified.

Mr. Whitaker was also the first to suggest the possibility of sub-dividing the Upper Chalk when in 1865 he distinguished the comparatively flintless chalk of the Margate cliffs from the very flinty chalk of Broadstairs and Ramsgate, the superposition of the former being so clear that he described the two divisions under the names of *Margate Chalk* and *Broadstairs Chalk.** These divisions, however, were based on lithological and not on faunal differences.

In 1870 Mr. Caleb Evans made an attempt to distinguish palæontological zones in the Chalk of Surrey, but the sections he described† only included the lowest part of the Upper Chalk. In this, however, he found two distinct life-zones: (1) that of *Holaster planus* and *Micraster corbovis*, (2) that of *Micraster coranguinum.*

In the same year appeared a paper by Mr. Dowker on the Chalk of Thanet and East Kent,‡ in which he referred to the sub-divisions previously made by Phillips, Conybeare, and Whitaker. He gives a complete section through the Kentish Chalk, and divides the upper part into three stages under the following names:—

1. Margate Chalk.
2. Ramsgate Chalk.
3. St. Margaret's Chalk.

The first is that which was so named by Mr. Whitaker; the second is the same as Mr. Whitaker's "Broadstairs Chalk," and coincides with Phillips' "chalk with many layers of flints"; the third is the nodular chalk with scattered flints, which includes the equivalent of the Chalk Rock. It is an accident that Mr.

---

* Quart. Journ. Geol. Soc., Vol. xxi. p. 395.

† "On some Sections of Chalk between Croydon and Oxtead." Geol. Assoc., Lewes, 1870.

‡ Geol. Mag. Vol. vii., p. 466 (1870).

Dowker's divisions correspond closely with modern zones, for he expressly says that he "does not believe much in the evidence of fossil zones."

It may safely be stated, however, that without a close and careful study of the fossils it would have been quite impossible to identify the Ramsgate and Margate divisions in other parts of England; because the lithological peculiarities which these divisions present in Kent are not constant throughout the country. All recent progress in our knowledge of the Upper Chalk has been gained by a study of its fossils and by adopting the zonal method of investigation. A chapter on "The Value of Zones in the Cretaceous System" was published in Volume I., and it may be asserted that the study of the Upper Chalk is especially and essentially a study of zones.

The establishment of a succession of zonal sub-divisions in this part of the Chalk has not been a difficult task, because the formation is exposed in so many fine cliff sections along our southern coast, but the establishment of such a zonal succession is one thing and the mapping or following of each zone through inland areas is another and much more difficult matter. It is more difficult because it is seldom that inland exposures show continuous sections for more than 60 or 70 feet; because old quarries become obscured by the growth of talus-slopes; and because only small spaces are accessible for the purpose of collecting fossils. Hence it is often impossible to obtain a sufficient number of fossils from an inland exposure to determine the zone to which the chalk belongs or to ascertain whether more than one zone is exposed.

At present, therefore, there are many gaps in our knowledge of the inland areas of Upper Chalk, and it is chiefly by the careful collecting of local observers that these deficiences can be made good. Much has already been done, especially by Dr. Blackmore, near Salisbury; by Mr. Meyrick, near Marlborough; by Mr. Ch. Griffith and Mr. R. M. Brydone, in Hampshire; by Mr. Dibley, in Kent, and by Mr. Stather, in Yorkshire; and to all these gentlemen I am much indebted for their readiness to impart information and lists of fossils. In spite of their assistance, however, and of the information thus added to the observations of Mr. W. Hill and myself, we feel that much still remains to be done before our knowledge of the inland areas of the Chalk can be made anything like complete. Those of the following chapters which deal with such areas must therefore be regarded merely as contributions to such knowledge, but they will, I hope, serve to show the lines on which further investigation will be productive of good results.

Of the sections exposed in the cliffs of our southern coasts it is possible to give much more complete descriptions, and in this connection we desire to express our high opinion of the value of the work done by Dr. A. W. Rowe, whose papers have added much to our knowledge, and have afforded us much assistance, more especially in dealing with the coasts of Sussex and of Dorset. We also fully accept his work on the British species of *Micraster* and his able discrimination of the different forms and their varieties which have proved so useful in the delimitation of the lower zones of the Upper Chalk.

ZONAL SUB-DIVISION OF THE UPPER CHALK.

The first to attempt a systematic zonal sub-division of the whole English chalk was Professor Ch. Barrois, of Lille. His excellent account of the chalk of the Isle of Wight was published in 1875, and his larger Memoir, "Sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irelande," in 1876. The zones into which he divided the Upper Chalk, and which he described throughout the South of England, as well as in Norfolk and Yorkshire, were the following :—

1. Zone à Belemnitelles.
2. Zone à Marsupites.
3. Zone à Micraster coranguinum.
4. Zone à Micraster cortestudinarium.
5. Zone à Holaster planus.

Only the first four of these were grouped by him in the Senonian, the lowest being classed with the Turonian, as was, and still is, customary in France. It should be observed, however, that these zones were not quite identical with those which had been previously established in France, mainly by the researches of Edmond Hébert. These zones were :—*

1. Zone of Belemnitella mucronata.
2. Zone of Belemnitella quadrata.
3. Zone of Micraster coranguinum.
4. Zone of Micraster cortestudinarium.
5. Zone of Holaster planus.

It will be noticed that in Hébert's scheme there is a zone of *Belemnitella (Actinocamax) quadrata*, which does not appear in that of Professor Barrois, whose zone of *Marsupites* would seem to take its place. This, indeed, is really the case, for although Professor Barrois states, on p. 21 of his "Recherches," that his zone of *Marsupites* was formed at the expense of Hébert's zone of *Micraster coranguinum*, and corresponds to the upper part of that zone, yet he includes in his zone of *Marsupites* all the chalk of the Sussex cliffs between Brighton and Newhaven, the chalk of Harnham, near Salisbury, and the flintless chalk of Yorkshire, all of which are certainly referable, in part at least, to the zone of *Act. quadratus*. Moreover, when dealing with the chalk of Yorkshire, Professor Barrois recognised that the chalk which contains *Marsupites, Actinocamax Merceyi* (= *A. granulatus*), and *Act. quadratus* is the equivalent of the "quadrata" chalk of Germany, and he remarks: "I consider it therefore as proved that the zone of

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* Geol. Mag., Vol. vi. (1869), p. 200, and Bull. Soc. Géol. de France, Ser. 3, T. iii. p. 595 (1875).

Marsupites in England corresponds to the *Senonien à Bel. quadrata* in the north-west of Germany." (Recherches, p. 199.)

The fact is that Barrois' "zone *à Belemnitelles*" was really the zone of *Belemnitella mucronata* only, and did not include that of *Act. quadratus* (as may be seen from the table at the end of this volume); while his zone of *Marsupites* included a great thickness of chalk in which *Marsupites* have never been found, but in which both *Act. quadratus* and *Act. granulatus* are common.

At the same time, full credit must be given to Professor Barrois for being the first to demonstrate the wide extension of the chalk which does contain *Marsupites*, and for correctly indicating its position between the flinty chalk of the *Micraster coranguinum* zone and the chalk in which *Belemnites* are common; for it had previously been supposed that the Margate Chalk was of about the same age as the Norwich Chalk.

The careful collecting of fossils near Salisbury by Dr. H. P. Blackmore and Mr. E. Westlake, as well as in Kent and Sussex by Dr. A. W. Rowe and Mr. C. D. Sherborn, has fully established the position of the Marsupite chalk. There is now no doubt that both *Marsupites* and the allied genus *Uintacrinus* are restricted to a certain thickness or zone of chalk, and that these peculiar Crinoids are associated with a small but distinct zonal fauna.

The zone of *Actinocamax quadratus*, has also undoubtedly a fauna of its own, which is distinct from that of the underlying zones, and from that of the overlying *Bel. mucronata* zone. It can be recognised wherever a sufficient thickness of chalk emerges from beneath the transgressive and unconformable Eocene Series. In 1878 Prof. Barrois himself acknowledged the existence of this zone in France,* and it has been recognised in England by Mr. Westlake,† by Dr. Blackmore,‡ and by Dr. A. W. Rowe.‖

In his Memoir on the Ardennes, Professor Barrois retained a zone of *Marsupites*, and referred the chalk of St. Omer to this zone, although no remains of *Marsupites* have yet been found there. He still considered, however, that his zone of *Marsupites* was formed at the expense of Hébert's zone of *Micraster coranguinum*, and he proposed to designate the lower part of this chalk by the name of *Inoceramus involutus*, these two zones making up an "assise à *M. coranguinum*" thus—

$$\left.\begin{array}{l}\text{Zone of } \textit{Marsupites} \\ \text{Zone of } \textit{In. involutus}\end{array}\right\}\text{Assise of } \textit{M. coranguinum}.$$

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* Le Terrain crétacé des Ardennes, Ann. Soc. Géol. Nord, T. v. p. 480.

† Tabular Index to the Upper Cretaceous Fossils cited by Dr. Ch. Barrois Fordingbridge, 4to. (1888).

‡ Notes on the Aptychi from the Upper Chalk, Geol. Mag., Dec. 4, Vol. iii. p. 529 (1896).

‖ The Zones of the White Chalk of the English coast, I. Kent and Sussex, Proc. Geol. Assoc., Vol. xvi. p. 290 (1900). II. Dorset, Id. Op. vol. xvii., p. 1 1901).

It does not, however, seem at all certain whether the French equivalent of the Marsupite chalk was really included in Hébert's zone of *Micr. coranguinum*,* but in any case I prefer the plan adopted by Professor Barrois in his "Recherches," where he retained the term "zone of *Micraster coranguinum*" for the chalk below the Marsupite zone.

With respect to the lower zones, these have already been discussed in Vol. II. p. 360, where it was explained that the arrangement adopted on the maps of the Geological Survey will also be employed in this Memoir. This arrangement includes the Chalk Rock and the zone of *Holaster planus* in the Upper Chalk.

The highest chalk in England is found on the coast of Norfolk near Trimingham and Mundesley, and as this contains a special fauna of its own we propose to separate it as the zone of *Ostrea lunata*.

In this Memoir, therefore, the Upper Chalk will be regarded as consisting of the following zones :—

B.
- Zone of *Ostrea lunata.*
- Zone of *Belemnitella mucronata.*
- Zone of *Actinocamax quadratus.*
- Zone of *Marsupites testudinarius.*

A.
- Zone of *Micraster coranguinum.*
- Zone of *Micraster cortestudinarium.*
- Zone of *Holaster planus.*

It will be seen that we have grouped the three lower zones as a division A, and the four upper zones as division B, and we have done so to mark our belief that the Upper Chalk includes more than one division of the value of a stage. The fauna of group A, regarded as a whole, contains many species and varieties which do not range up into the beds of group B, while others occurring in the higher zones do not occur below. Division A is essentially the chalk with Micrasters, and division B is essentially the chalk with *Belemnites*.

Our knowledge of the several faunas, however, is not yet sufficiently complete to enable us to say precisely where a line could best be drawn between the two divisions or stages, and it is possible that some modifications of the zones will have to be made before two such stages can be established. Moreover, if such a division be found natural and desirable the existing nomenclature of the chalk will have to be abandoned, for the formation will then be divided into four parts instead of three, so that the names Lower, Middle, and Upper could no longer be retained. The time has hardly yet arrived for this change to be made, but Mr. Hill and I wish to express our belief that it will come, and that some scheme of nomenclature more resembling that of the French geologists will have to be adopted for the Upper Cretaceous Series of England.

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* M. de Grossouvre has recently shown that the zone of *arsupites* is the equivalent of his zone of *Placenticeras syrtale* and that it lies below the *Act. quadratus* zone. See his Recherches sur la Craie Supérieur, p. 799 (1901).

Zone of Holaster planus.

This zone was first distinguished from the overlying chalk near Dieppe by Professor Hébert in the year 1866,* and in 1869† he recognised the same horizon in the Chalk Rock described by Mr. Whitaker. He was also the first to recognise its equivalent in the cliffs near Dover, which he described in 1874.‡ It there forms the lower part of the St. Margaret's Chalk of Mr. Dowker, and the " chalk with interspersed flints " of W. Phillips.

The zone was adopted by Prof. Barrois in 1876, and a zone of *Holaster planus* has been accepted by all subsequent observers, though there have been differences with regard to its limits.

The chalk of this zone varies much, both in its lithological characters and also in its fossil contents ; in fact, it presents three very different facies in different parts of England, and these may be called the southern, the midland, and the northern facies.

The southern facies, well exposed at Dover, exhibits a series of alternating harder and softer beds, the former consisting of lumps of hard, compact chalk set loosely in a softer matrix. These lumps have a yellowish tinge and have a tendency to form layers ; sometimes, indeed, being so closely packed as to form a hard, rocky layer. The softer beds between are either greyish white or are streaked with grey. Flints occur throughout, generally scattered, and seldom forming a regular continuous layer. This facies occurs all round the Wealden area, through Hants and the Isle of Wight, and with slight variations into South Dorset and Devon.

Another facies, that of the Chalk Rock, ranges along the main outcrop from the north of Dorset to Cambridgeshire, and this rock must be considered as a condensed equivalent of the southern type, for it is sometimes not more than 4 or 5 feet thick. The Chalk Rock proper must be distinguished from the Chalk Rock-beds, which often exhibit a lower and an upper rock-bed separated by a variable thickness of loose nodular chalk.

The Chalk Rock in its most solid form consists of several beds of hard compact limestone, each terminating upward in a layer of green coated nodules of compact yellowish and slightly phosphatic limestone. It frequently contains glauconite, and sometimes the grains are so numerous that it may be described as a glauconitic limestone. It is very variable in thickness and in its aspects, as well as in the number of fossils it contains, these being abundant in some places and very rare in others. Flints seldom occur in the Chalk Rock, except in that of Wilts and Dorset.

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* Comptes Rendus de l'Acad. des Sciences for 1866.

† See Geol. Mag., Vol. vi. p. 200. (1869).

‡ Bull. Soc. Géol. France, S. 3, Vol. ii. p. 416.

The third, or northern, facies is found in Norfolk, Lincolnshire and Yorkshire. In Norfolk it appears as a band or zone of rather hard white chalk with frequent layers of flints, but without any nodular beds or other special features. In Lincolnshire there is a zone of similar chalk. In Yorkshire there is a great thickness of very hard white chalk which is nearly homogeneous, lies in thick beds, and contains frequent layers of flints which are grey or greyish black inside.

The characteristic fossils of this zone, and especially of the Chalk Rock, are—*Heteroceras reussianum*, *Ammonites* [*Pachydiscus*] *peramplus*, *Scaphites Geinitzi*, *Trochus Schlüteri*, *Solariella gemmata* (= *Turbo gemmatus*), *Holaster planus*, *Micraster Leskei*, and *Camerospongia campanulata*.

Zone of Micaster cortestudinarium.

We have retained this zone because it can sometimes be distinguished from that of *Holaster planus*, but we doubt whether its fossils really form a separate zonal assemblage and think that in the future it may be found more in accordance with the facts of the case to consider the two as forming one zone, in which two sub-zones can sometimes be recognised.

The zone of *Micraster cortestudinarium* was established in France by Professor Hébert (1866) and was also identified by him in the Dover cliffs (1874).* Its wider extension through England was indicated by Dr. Barrois in 1876.† It coincides with the upper part of what W. Phillips called " the chalk with interspersed flints " at Dover, which was subsequently called the St. Margaret's Chalk by Mr. Dowker.‡

In the south of England the chalk of this zone is practically a continuation of the zone of *Holaster planus*, and its upper limit is not always very clearly marked. Moreover, there are few fossils which are specially characteristic of it; the Micrasters which occur have certain special features, and belong to the *præcursor* group of Dr. Rowe;§ some of the varieties resemble *M. cortestudinarium* in many respects, but few of them have the breadth and depressed outline of Goldfuss' type of that species. *Holaster placenta* is a species which both Professor Hébert and Dr. Rowe have have found to be not uncommon in this zone near Dover, in Sussex and in Dorset, but we do not yet know whether it occurs in other parts of the country. *Holaster planus* is also found, but not so commonly as in the zone below.

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* Bull. Soc. Géol. Franc., Ser. 3, Vol. ii. p. 416.

† Recherches sur le Terr. Crét. Sup. de l'Angleterre, Lille (1876)

‡ See Geol. Mag., Vol. vii. p. 466 (1870).

§ Quart. Journ. Geol. Soc., vol. lv. p. 530. (1899).

Dr. A. W. Rowe is of opinion that in the south of England this zone can always be distinguished from that of *Holaster planus* by the character of the Micrasters. *Micraster Leskei* and *M. corbovis* do not occur, but special varieties of *M. præcursor* and *M. cortestudinarium* are common. He says, "We find no Micraster with 'smooth' or 'sutured' ambulacra in this zone, but they are all of the 'strongly inflated,' or more commonly of the 'sub-divided' type. This applies equally to broad and narrow forms."*

Where Micrasters are sufficiently abundant they will, if closely studied, doubtless serve to distinguish this from the zones above and below, but where Micrasters are rare, as in some counties, this evidence fails us; and Dr. Rowe does not mention any other fossil which would assist us in distinguishing the two zones. It is true that several species which are common in the zone of *Hol. planus*, such as *Terebratula carnea*, and *Pentacrinus Agassizi*, are rare or absent in the upper zone, but the fact remains that there are many inland localities where it is difficult to distinguish one zone from the other.

In the south of England this zone consists in the lower part of rough nodular chalk, often greyish-white or white with grey streaks and bands. The flints in this part are generally compact and solid, either black or grey inside, and often with a thick white rind. The higher part of the zone consists of firm whitish chalk, often rather rough and lumpy, never quite homogeneous, and frequently stained yellow in the cracks. Layers of hard nodular chalk occur at intervals. Its flints are often of the *carious* type—that is to say, they are full of holes and cavities, with a rough external surface, and generally contain remains of Sponges. With these are some solid dark-grey flints, which also contain many sponge spicules. The flints are for the most part scattered irregularly through the Chalk, but in the higher portion of the zone layers of flints occur, and there are also some continuous layers or floors of flint.

In the valley of the Thames and in the counties to the northward this zone consists chiefly of smooth white chalk, nodular beds occurring only at distant intervals; moreover, fossils are scarce in it, so that it is difficult to determine where it begins or ends. Still further north, in Norfolk, Lincolnshire, and Yorkshire there are no nodular beds, and fossils are equally scarce, so that the same difficulty exists.

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* On the Zones of the White Chalk of the English Coast, Proc. Geol. Assoc. Vol. xvi. p. 309 (1900). For the characters of the Micrasters, see Dr. Rowe's Memoir in Quart. Journ. Geol. Soc., Vol. lv., p. 494 (1899), and the brief descriptions given hereafter on pp. 22 to 27.

Zone of Micraster Coranguinum.

A zone of *Micraster coranguinum* was first established by Hébert in 1863,* to include all the chalk between the zone of *M. cortestudinarium* and that which contained *Actinocamax quadratus*, but he afterwards divided it into two parts, the lower of which he called the " chalk with banded flints " (*silex zonés*), and the upper was (in France) " chalk with cavernous flints " (*silex cariés*).

In England, however, cavernous flints are most abundant in the lower part of the zone, and banded flints higher up, so that, as Professer Barrois pointed out in 1878,† the characters of the flints are not maintained over large areas, though they are useful within limited districts.

The chalk of this zone is generally pure white, firm and homogeneous, but some beds both in the lower and upper part of it are full of fragments of Inoceramus-shell, some large, and some small, and even when these are too small to be visible to the eye, they give a character to a slide of this chalk under the microscope.

The fossils which are usually to be found in this zone are *Micraster coranguinum* and its variety *latior*, *Galerites albogalerus*, *Epiaster gibbus*, *Cidaris sceptrifera*, *C. peromata*, *Inoceramus involutus*, and in the south of England the small *Actinocamax verus* occasionally occurs in the highest part of the zone, but other Belemnites are rarely found.

The flints are very numerous, occurring chiefly in regular layers at short distances apart, and there are also continuous seams or floors of flint. In the lowest beds various flints containing remains of *Doryderma ramosum* are frequent, and above them there are often beds which contain the" silex à zones nuageuses " of Professor Barrois, solid black or brownish flints which have a milky white band or zone near the outer margin, but separated from it by a margin of ordinary dark flint. The highest beds in Wilts and Dorset have flints with thick rinds which often consist of separate grey and pink layers, and thus have an agate-like appearance.

Zone of Marsupites testudinarius.

The zone of Marsupites was founded by Professor Barrois in 1876, as already mentioned. The chalk of which it consists is soft white, homogeneous and brittle. Sometimes it is massive and traversed by long joints, sometimes it is distinctly bedded, and includes many thin seams of marl.

It always contains fewer flints than the zone below, and sometimes (as at Margate and in Yorkshire) it is almost destitute of flints. When flints occur they are always solid and black inside, with a white rind or cortex, but the thickness of this rind varies; in Eastern Sussex it is thin, but in Wilts, where the zone is much thicker, the flints in the lower part have hardly any rind at all, while those in the upper part have a thick, dull white rind from a third to more than half an inch thick.

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* Bull. Soc. Géol. de France, Ser. 2, Vol. xx. p. 609.

† Terrain Crétacé des Ardennes, Ann. Soc. Géol. Nord, T. v. p. 445.

In the south of England the depth or thickness of this zone seems to be from 90 to 120 feet, but in Yorkshire there is about 400 feet of flintless chalk which seems to be referable to it.

The most characteristic fossils of the zone besides *Marsupites* are *Uintacrinus westfalicus, Echinocorys scutatus, var. pyramidatus, Actinocamax verus, Act. granulatus* (= *A. Merceyi*), *Ammonites* [*Haploceras*] *leptophyllus*, and a species of *Terebratulina* recently described by Dr. Kitchin as *Ter. Rowei*. In the south of England the zone seems to be always divisible into a lower and an upper part; the lower part is termed by Dr. Rowe[*] the *Uintacrinus* Band, and the upper part the *Marsupites* Band, from the restricted occurrence of the plates of these Crinoids. In the same way *Act. verus* only occurs in the lower band and *Act. granulatus* chiefly in the upper band.

This zone has been recognised in Kent, Sussex, Hampshire, Wiltshire, Dorset, the Isle of Wight, Suffolk, Norfolk and Yorkshire. It probably exists beneath some parts of the London Basin, but the only places within the cincture of that basin where Marsupite plates have yet been found are Margate in Kent, Chinham in Hants, and Monks Eleigh in Suffolk.

Zone of Actinocamax quadratus.

This zone, originally known as that of *Belemnitella quadrata*, was recognised by Strombeck in Germany about 1855, and by Hébert in France in 1863,[†] but it was not till 1869, that it was definitely separated from the Meudon chalk or zone of *Belemnitella mucronata* in the Paris Basin. Professor Barrois recognised its existence in Yorkshire in his "Recherches" of 1876, but not in the south of England, where its establishment has been due primarily to Dr. H. P. Blackmore and Mr. E. Westlake, and where it has been studied more recently by Dr. A. W. Rowe.[‡]

The chalk of this zone is white, firm, and regularly bedded, and in the east of England it contains numerous thin seams of marl. Generally, also, it has many layers of flints, but these are never so close together as in the zone of *Micraster coranguinum*, being seldom less than 3 feet apart, and often only at intervals of 6, 8, or 9 feet. Thin seams of continuous flint are common in this chalk, and some oblique fissures are also filled with flint. The flints are always solid and black inside, and generally have a moderately thick rind from ⅛ to ¼ of an inch deep. Sometimes, however, or perhapsin some parts of this zone, the flints have very thick white rinds. In Sussex Dr. Rowe found the rinds to be generally pink.

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[*] The Zones of the White Chalk, Proc. Geol. Assoc., Vol. xvi. p. 296.

[†] Bull. Soc. Géol. de France. Ser. 2, t. xx., p. 565.

[‡] For references, see pp. 81 and 97.

The zone of *Act. quadratus* has been traced throughout the Hampshire Basin from Sussex to Dorset; it emerges from beneath the overstep of the Eocenes in Suffolk, and can be followed thence to the north coast of Norfolk. Its further extension lies chiefly beneath the sea outside the coast of Lincolnshire and Yorkshire, but comes into the cliffs again near Bridlington, and forms the upper part of the flintless chalk of Yorkshire.

Dr. Rowe states that the passage from the zone of *Marsupites* to that of *Act. quadratus* in Sussex is marked by a kind of neutral band, in which neither *Marsupites* nor *Offaster pillula* are found, but in which *Actinocamax granulatus* occurs, a species which is common to both zones; this neutral band is about 20 feet thick.

Fossils are not always abundant in this zone, and the characteristic Belemnite appears to be rare in the lower beds, but *Offaster pillula* ranges from base to summit, and is generally to be found, occurring at some horizons in great abundance. *Belemnitella lanceolata* occurs in some districts, and Dr. Rowe observes that a species of *Bourgueticrinus*, not yet described, is characteristic of this zone. He also mentions certain Bryozoa as good zonal guides, especially *Vincularia santonensis* and *Eschara Danaë*, and a special form of *Cribrilina*.

From the above it will be seen that in England the *Belemnite* from which the zone has been named is not a very good index or guide fossil, while *Offaster pillula* is common, and is almost restricted to the zone. On this point Dr. Rowe remarks—"Were not *Belemnitella mucronata* such an excellent name-fossil for the zone above, thus giving a continuity between the two species, it would be much better to do away with the present name for the lower zone as far as England is concerned."* He suggests that it might be called the zone of *Offaster pillula*, and that it may admit of division into two sub-zones, a lower characterise dby *Actinocamax granulatus*, and an upper by *Act. quadratus*. This proposal has much to recommend it, but in the present memoir I have thought it best to retain the original name of the zone.

Zone of Belemnitella mucronata.

The zone of *Bel. mucronata* has been long established both in Germany and France. In France it is also known as the Chalk of Meudon, and in England its best known exposure is the Chalk of Norwich. It was first recognised as a zone in this country by Professor Barrois, though he did not clearly separate it from the zone of *Act. quadratus*. His *zone à Belemnitelles* does, however, consist for the most part of the *Bel. mucronata* chalk, which is certainly distinguishable from the zone of *Act. quadratus*.

The chalk of this zone is soft, white, and pure. Flints are not very abundant, at any rate in the lower part, where they are always small; in the higher part they are more numerous, and very large cup-shaped or cylindrical flints sometimes occur of the kind which have been called "Paramoudras."

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* Proc. Geol. Assoc., Vol. xvi., p. 345

It is only in the central parts of the Cretaceous basins that this zone is found, and the thickness exposed varies greatly because of the unconformity between the Cretaceous and Eocene systems. In the Hampshire basin its maximum thickness is probably 250 feet. It has apparently been entirely removed from the southern part of the London Basin, and is only found again in the northern prolongation of that basin, *i.e.* in Norfolk, where its full thickness must be present, although its surface is for the most part hidden beneath the Crag and Drift deposits.

As to fossils, *Belemnitella mucronata* is so common that it may almost always be found in a good exposure of this chalk, *Bel. lanceolata* is also common in Dorset and in the Isle of Wight. *Magas pumilus* and *Rhynchonella limbata* are of frequent occurrence, and Dr. Blackmore informs me that in the Hampshire Basin *Crania egnabergensis, var. costata,* is specially characteristic of this zone. *Cardiaster ananchytis* is not rare; spines of *Cidaris serrata* and *C. subvesiculosa* are sometimes common, and a thin-shelled *Micraster*, considered by Professor Barrois to be *M. Brongniarti* occurs in Dorset, but is rare.

Zone of Ostrea lunata.

This zone is now proposed for the first time in order to separate the chalk, exposed on the coast of Norfolk, near Trimingham and Mundesley, from the rest of the English Chalk. Not only are these beds the highest and newest chalk in England, but they contain a fauna which differs from that of the Norwich chalk, and includes some species which are common in the chalk of Rügen and Maestricht. The flints which they contain also differ from those of the Norwich chalk, being for the most part small, and having a rough outer surface; many are hollow, and are filled with a greyish chalk, which is rich in sponge spicules, foraminifera, and other small fossils.

Ostrea lunata abounds in this chalk, and other characteristic fossils are *Pecten serrat* , *Galerites abbreviatus* (=G. *Rœmeri*), *Trochosmilia cornucopiœ, Thecidium vermiculare, Terebratulina Gisei*, and the large typical form of *Terebratulina gracilis*, which is not found elsewhere in England. There are also a number of Bryozoa, many of which do not occur elsewhere in England.

Unconformity of the Eocene.

The top of the Upper Chalk is not to be found anywhere in England, and a study of the Upper Chalk zones has proved that the Eocene is completely unconformable to the Chalk, resting in some districts on the zone of *Belemnitella mucronata*, sometimes on that of *Act. quadratus*, sometimes on the zone of *Marsupites* or Margate Chalk; and in places on the zone of *Micraster coranguinum*, as in Surrey, Berkshire and Oxfordshire.

There are only two areas where anything like a complete succession of the *Senonian* zones is to be found, and these are the Hampshire Basin and Norfolk, but all the zones except that of *Belemnitella mucronata* seem also to be represented in the Upper Chalk of Yorkshire. The London Basin was an area of upheaval and erosion before the deposition of the Eocene, so that 200 or 300 feet of chalk appear to have been removed from it in the interval between the formation of the highest English Chalk and the lowest English Eocene.

Under these circumstances we cannot treat the Upper Chalk zones quite in the same way as those of the Lower and Middle Chalk. It will be more convenient to describe the development of the zones in the three areas mentioned above separately.

In the Hampshire Basin we shall describe the Upper Chalk of Sussex, South Hampshire, South Wilts, Isle of Wight, Dorset, and Devon. Then that of the counties which border the London Basin will be described, and finally that of Lincolnshire and Yorkshire, so far as those counties have been examined.

CHAPTER II.

FOSSILS OF THE UPPER CHALK.

The fauna of the beds which are in this memoir grouped as Upper Chalk is a very large one. It has been pointed out indeed in a previous volume that if a classification of the Chalk into three stages were based entirely on palæontological grounds the line between the Middle and Upper Chalk would not be drawn at the base of the zone of *Holaster planus*, but at some horizon above it. Thus, there are so many species which become rare or die out in the lower part of the *M. coranguinum* zone that the fauna of the lowest part of this "Upper Chalk" stands by itself, and in noticing the principal fossils of the division as a whole it will be convenient to mention first those which are found in the lower beds, and then those which occur chiefly or solely in the higher beds. By the phrase higher beds must be understood the upper part of the *M. coranguinum* zone and all that lies above it.*

Reptilia.—In the lower beds some of the Lower Chalk Reptiles still survive, such as *Cimoliosaurus Bernardi* and *Polyptychodon interruptus*. In the higher beds Mosasauroid Reptiles make their appearance, the most important being *Leiodon anceps* and *Mosasaurus Camperi*.

Pisces.—A great many of the fish found in the Lower and Middle Chalk range up into the Upper Chalk, even into the higher zones. A few species, however, are either more abundant in or restricted to the Upper Chalk; these are *Corax affinis*, *Corax pristodontus*, *Ptychodus Oweni*, *Synechodus dubrisiensis*, and *Belonostomus cinctus*.

Cephalopoda.—Of these, the following species occur in the lower beds, and are specially characteristic of the Chalk Rock:—

Ammonites [Prionocyclus] Neptuni, *Geinitz.*
„ [Pachydiscus] peramplus, *Mant.* (Fig. 1.)
Baculites bohemicus, *Fritsch*
Heteroceras reussianum, *d'Orb.* (Fig. 2.)
Ptychoceras Smithi, *Woods*
Scaphites Geinitzi, *d'Orb.*

Besides these, *Nautilus sublævigatus*, d'Orb. *N. fleuriausianus*, d'Orb. and *Crioceras ellipticum*, Mant. range up from the Lower Chalk.

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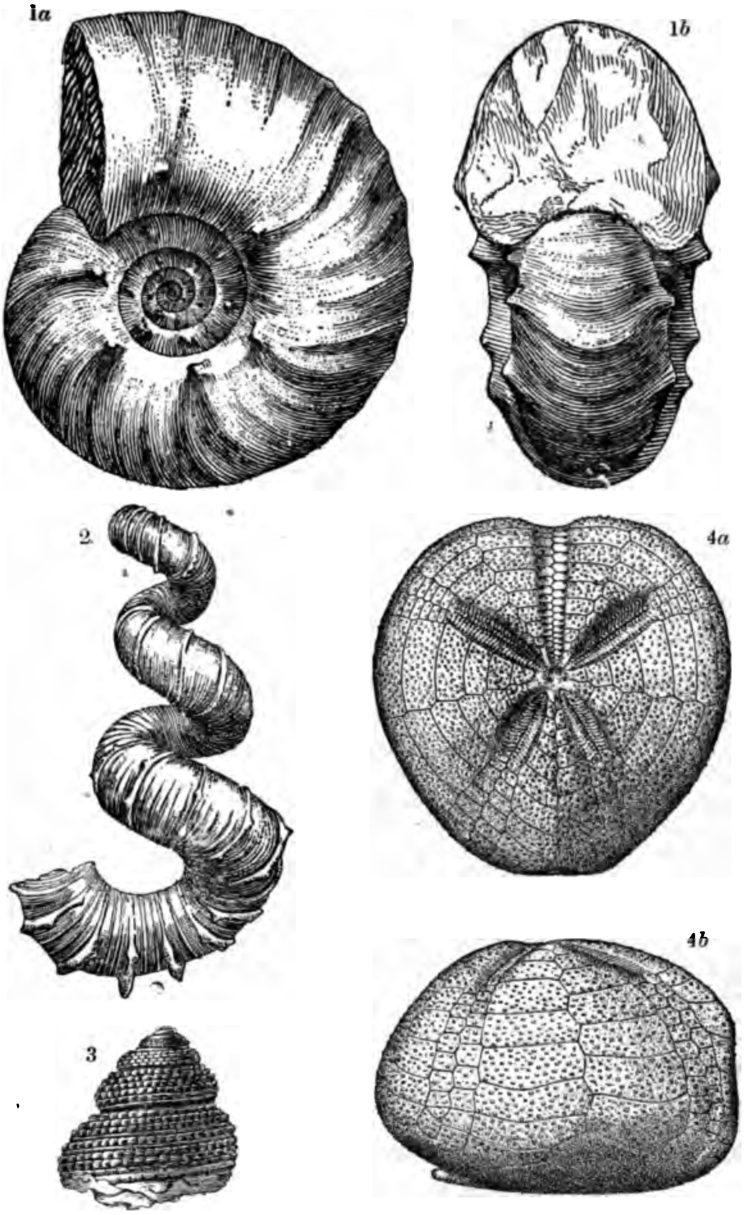
* This distinction coincides with the distribution of the Micrasters into a low zonal and a high zonal series, according to Dr. Rowe. See Quart. Journ. Geol. Soc., Vol. lv., p. 512.



UPPER CHALK FOSSILS (LOWER ZONES).

FIG. 1.—Ammonites [Pachydiscus] peramplus, *Mant.* (nat. size, middle-aged specimen). *a*, side view ; *b*, front view.

, 2.—Heteroceras reussianum, *d'Orb.* (nat. size).

„ 3.—Solariella gemmata, *Sow.* (Turbo gemmatus) (nat. size).

„ 4.—Micraster cortestudinarium, *Goldf.* (nat. size). *a*, apical view *b*, side view.

In the higher beds the following species are found :—

Ammonites [Haploceras] leptophyllus, *Sharpe*
„ „ icenicus, *Sharpe*
„ [Lytoceras] Jukesi, *Sharpe*
Baculites Faujasi, *Sow.*
Actinocamax granulatus, *Blainv.* (=Merceyi, *Mayer*)
„ quadratus, *Defr.* (Fig. 17.)
„ Toucasi, *Janet* (very rare).
„ verus, *Miller*
Belemnitella lanceolata, *Schloth.*
„ mucronata, *Schloth.* (Fig. 18.)

Gasteropoda.—Shells of this class are very rare in the higher beds, but are rather common in the Chalk Rock, of which the following species are characteristic :—

Avellana cf. Humboldti, *Müller*
Cerithium Saundersi, *Woods*
Natica vulgaris, *Reuss*
Solariella gemmata, *Sow.* [Turbo] (Fig. 3.)
Trochus Schlüteri, *Woods*
Turbo Geinitzi, *Woods*
Dentalium turoniense, *Woods*

Besides these *Aporrhais Mantelli,* Gard. and *Emarginula Sanctæ-Catharinæ,* Passy, range up from Lower Chalk, and *Pleurotomaria perspectiva,* Mant. ranges into the highest beds.

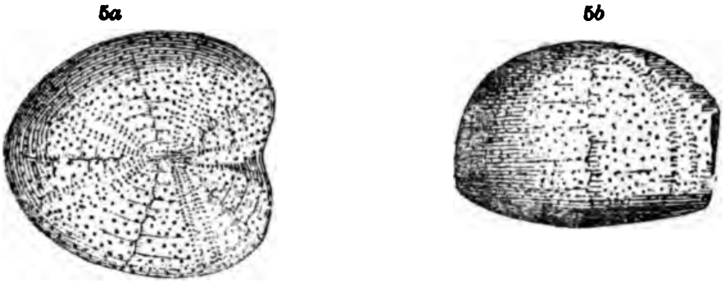
Lamellibranchiata are abundant in the Upper Chalk, and the following species range through both lower and higher beds :—

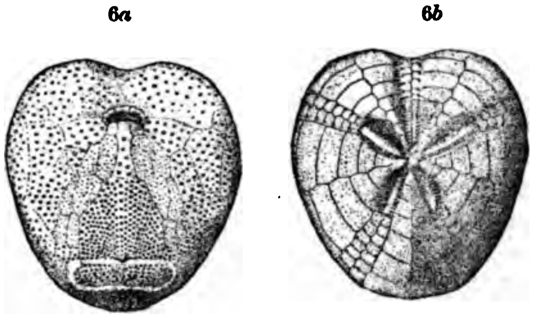
Ostrea canaliculata, *Sow.*
„ semiplana, *Sow.*
„ vesicularis, *Lam.*
Lima Hoperi, *Sow.* (Fig. 28.)
„ granosa, *Sow.*
Spondylus dutempleanus, *d'Orb.*
„ latus, *Sow.*
„ spinosus, *Sow.*
Septifer lineatus, *Sow.* (=Modiola Cottæ, *Roemer*)
Pecten cretosus, *Defr.* (=P. nitidus, *Mant.*) (Fig. 25.)

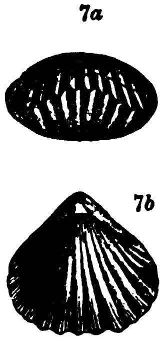
In the Chalk Rock beds there are a few species which do not seem to range higher, such as *Cardita cancellata,* Woods, *Cyprina quadrata,* d'Orb., *Trapezium trapezoidalis,* Roem., *Martesia rotunda,* Sow., and *Cuspidaria caudata,* Nilss.

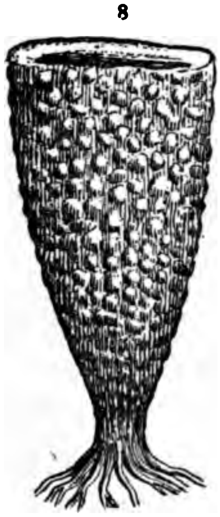
Of species which occur solely or most commonly in the higher beds the following may be mentioned :—

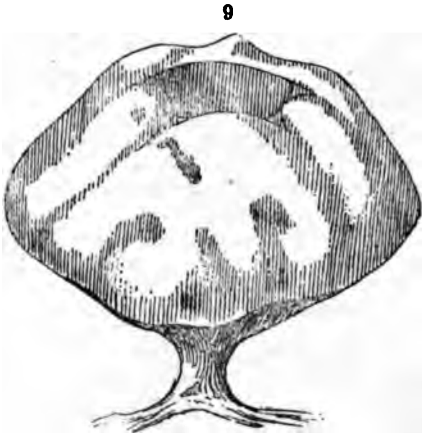
Inoceramus digitatus, *Sow.*
„ involutus, *Sow.* (Fig. 24.)
„ latus, *Mant.* (non *d'Orb.*)
Lima læviuscula, *Sow.*
„ granosa, *Goldf.*
Ostrea acutirostris, *Nilss.*
„ lunata, *Nilss.* (Fig. 27.)
„ wegmanniana, *d'Orb.*
Pecten mantellianus, *d'Orb.* (Fig. 26.)
„ Nilssoni, *Goldf.*











Upper Chalk Fossils (Lower Zones).

Fig. 5.—Holaster planus, *Mant.* (nat. size). *a*, apical view ; *b*, side view.
„ 6.—Micraster Leskei, *Desm.* (nat. size). *a*, basal ; *b*, apical view.
„ 7.—Rhynchonella reedensis, *Eth.* (nat. size), *a*, front view ; *b*, dorsal view.
„ 8.—Ventriculites mammillaris, *T. Smith* (nat. size).
„ 9.—Camerospongia campanulata, *T. Smith* (nat. size).

Inoceramus involutus, Sow., occurs in the middle part of the division (zones of *M. cortestudinarium, M. coranguinum*, and *Marsupites*).

Brachiopoda.—Most of the species of this group which occur in the Upper Chalk range throughout or nearly so, such are *Terebratula carnea*, Sow. (Fig. 16), *Ter. semiglobosa*, Sow., *Crania parisiensis*, Defr., *Kingena lima*, Defr., *Rhynchonella plicatilis*, Sow. (Fig. 22), *R. reedensis*, Eth. (Fig. 7), and *Terebratulina striata*, Wahl. None are confined to the lowest beds, but the following are characteristic of the higher zones:—

Crania egnabergensis, *Retz.*, var. costata, *Sow.*
Magas pumilus, *Sow.*
Rhynchonella limbata, *Schlüter*. (Fig. 23.)
Terebratulina gracilis, *Schloth.* (type form Fig. 19.)
„ Rowei, *Kitchin.*
„ Gisei, *Hag.* (Fig. 20.)
Thecidium vermiculare *Schloth.*
Trigonosemus elegans, *König.*

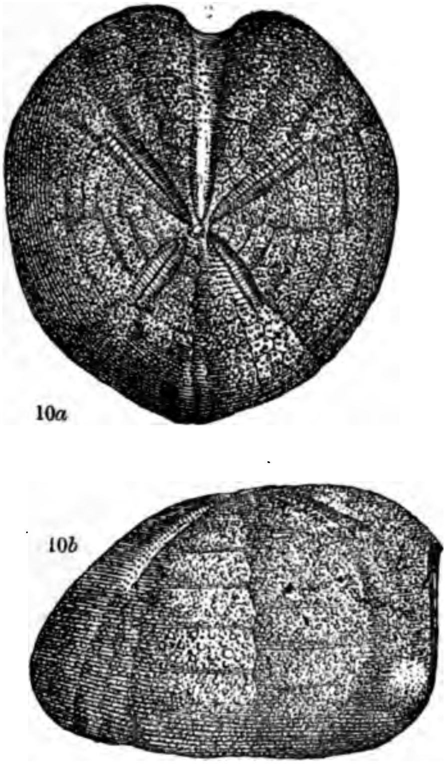
Bryozoa are very abundant in some parts of the Upper Chalk, especially in the zone of *M. cortestudinarium*, in the lower part of the *M. coranguinum* zone and in the zone of *O. lunata*. Mr. Gamble, of Chatham, has obtained a large number from the Chatham quarries and they are equally abundant at many other localities. Many of the adherent forms range throughout the Upper Chalk, but some appear to prevail at certain horizons, and when they have been more fully studied they may prove to have zonal limitations. The following are some of the commoner species:—

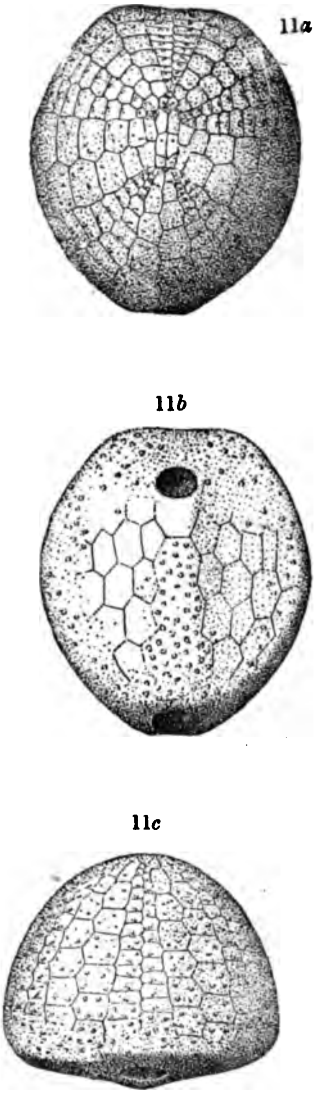
Stomatopora gracilis, *Edw.*
„ Dixoni, *Vine*
Diastopora papillosa, *Reuss.*
Proboscina ramosa, *Mich.*
Entalophora proboscidea, *Edw.*
Ceriopora polymorpha, *Goldf.*
Pustulipora pustulosa, *Goldf.*
Petalopora pulchella, *Roemer.*
Homœosolen ramulosus, *Mant.*
Lunulites cretaceus, *Defr.*
Eschara Acis *d'Orb.*
„ Danae, *d'Orb.*
Reticulipora obliqua *d'Orb.*
Desmepora semicylindrica, *Roemer*
Vincularia disparilis *d'Orb.*
„ santonensis, *d'Orb.*

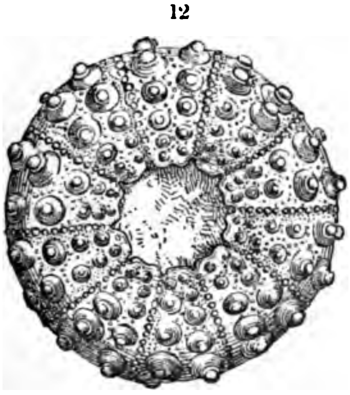
Crustacea.—Members of the order *Cirripedia* are fairly common in the Upper Chalk, belonging to the genera *Pollicipes* and *Scalpellum*. Of Decapoda *Enoploclytia Leachi*, Mant. and *E. sussexensis*, Mant. are found occasionally.

Annelida are very abundant, and a number of small species occur on the tests of the larger Echinoderms, and on the shells of Oysters and Inocerami. Among the most frequent species are:—

Serpula ampullacea, *Sow.*
„ carinata, *Woodw.*
„ fluctuata, *Sow.*
„ granulata, *Sow.*
„ macropus, *Sow.*
Serpula ilium, *Sow.*
„ plana, *Woodw.*
„ plexus, *Sow.*
„ vortex *Woodw.*
„ turbinella, *Sow.*







Upper Chalk Fossils (Higher Zones).

Fig. 10.—Micraster coranguinum, *Leske* (nat. size). *a*, apical view; *b*, side view.

„ 11.—Offaster pillula, *Lam.* (twice nat. size). *a*, apical view; *b*, basal view; *c*, anterior end.

„ 12.—Cyphosoma Kœnigi, *Mant.* (nat. size). Lower (oral) surface.

Echinodermata.—Echinoderms form a conspicuous feature in the fauna of the Upper Chalk. A certain number are confined to, or commoner in, the lower beds. These are:—

Cyphosoma radiatum, *Sorig.*
Holaster planus, *Mant.* (Fig. 5.)
„ placenta, *Ag.*
Micraster Leskei, *Desm.* (=M. breviporus, *Ag.*) (Fig. 6.)
„ præcursor, *Rowe*
„ cortestudinarium *Goldf.* (Fig. 4.]

Among the Echinoidea which either range throughout the Upper Chalk or are commoner in the upper zones, the following may be mentioned:—

Echinocorys scutatus, *Leske.* (Fig. 13.)
Cidaris clavigera, *König*
„ perornata, *Forbes*
„ sceptrifera, *Mant.*
„ subvesiculosa, *d'Orb.*
Cyphosoma corollare, *Klein*
„ Kœnigi, *Mant.* (Fig. 12.)
Galerites albogalerus, *Leske.* (Fig. 14.)
Micraster coranguinum, *Leske.* (Fig. 10.)
Cardiaster ananchytis, *Leske*
Infulaster excentricus, Rose
Hagenovia rostrata, *Forbes*
Offaster pillula, *Lam.* (Fig. 11.)
Epiaster gibbus, *Lam.*
Salenia geometrica, *Ag.*

The Crinoidea are represented by *Bourgueticrinus ellipticus*, Miller, which has a long range, perhaps from base to summit, *Marsupites testudinarius*, and *Uintacrinus westfalicus*, which have a very restricted range. The plates of *Uintacrinus* differ from those of *Marsupites* in being irregularly polygonal and in having strong ridges on the inner surface.

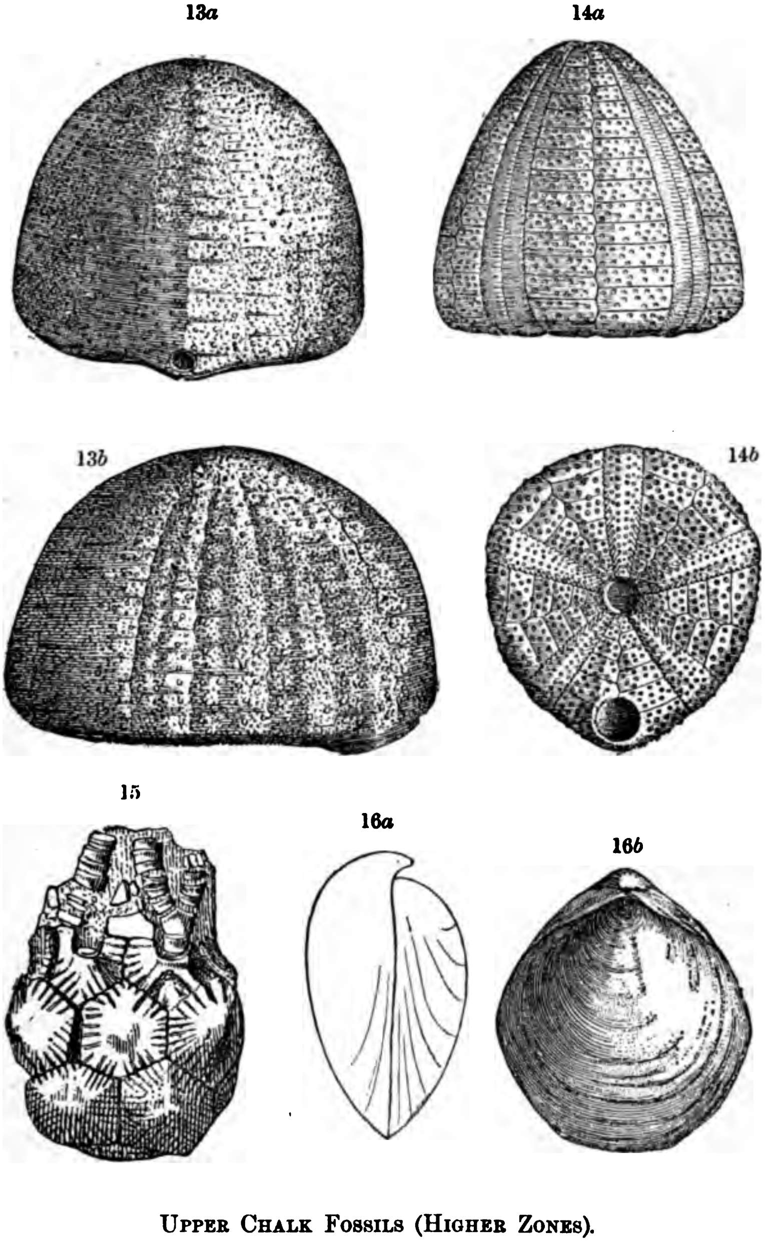
Asteroidea, or Starfish, are also abundant, the detached ossicles being very common, but more or less perfect specimens are not unfrequently found. The species seem to have a wide range, and those best known are the following:—

Metopaster Mantelli, *Forbes*
„ Parkinsoni, *Forbes*
„ zonatus, *Sladen*
„ uncatus, *Forbes*
Oreaster bulbiferus, *Forbes*
Oreaster pistilliferus, *Forbes.*
Mitraster Hunteri, *Forbes*
„ rugatus, *Forbes*
Pentagonaster megaloplax, *Sladen*
Pycnaster angustatus, *Forbes*

Actinozoa.—The corals which occur in the Upper Chalk are mostly small, the largest being *Caryophyllia cylindracea*, which sometimes grows to a length of 3 or 3½ inches. Besides the cup corals, of which the commonest are *Caryophyllia* and *Parasmilia centralis*, there are several adherent corals belonging to the genera *Axogaster*, *Diblasus*, and *Epiphaxum*.

Most of the species range through the division, but the genus *Cœlosmilia* (with five or six species) has only been found for certain in the highest zones (those of *Actinocamax quadratus*, *Belemnitella mucronata* and *Ostrea lunata*).

Spongida.—The remains of siliceous sponges are very common fossils in the Upper Chalk. A few seem to occur chiefly in the lower beds and some in the highest beds (zones of *A. quadratus*, *Bel. mucronata*, and *Ostrea lunata*), but a great



UPPER CHALK FOSSILS (HIGHER ZONES).

FIG. 13.—Echinocorys scutatus, *Leske* (nat. size). *a*, posterior view; *b*, side view.

„ 14.—Galerites albogalerus, *Leske* (nat. size). *a*, side view; *b*, basal view.

„ 15.—Marsupites testudinarius, *Schloth.* (nat. size).

„ 16.—Terebratula carnea, *Sow.* (nat. size). From Norwich.

many range from the *Hol. planus* to the *Bel. mucronata* zone. The following occur specially in the lower beds :—

Camerospongia campanulata, *T. Smith.*
„ subrotunda, *Mant.*
Cephalites Benettiæ, *Mant.*
„ perforatus, *T. Smith.*
Guettardia stellata, *Mich.*

Ventriculites are also common in these lower, but most of the species range upwards into the higher zones. Among them may be mentioned, *V. alcyonoides*, Mant., *V. cribrosus*, Phil., *V. decurrens*, T. Smith, *V. impressus*, T. Smith, *V. mammillaris*, T. Smith (Fig. 8).

Other sponges which range through several zones are *Doryderma ramosum*, Mant., *Plinthosella squamosa*, Zitt., *Plocoscyphia convoluta*, and *Heterostinia obliqua*, Benett.

Of species which are characteristic of the higher beds the following may be mentioned :—

Cœloptychium agaricoides, *Goldf.*
Jereica clava, *Lee.*
Pachastrella convoluta, *Hinde.*
Plinthosella compacta, *Hinde.*
Porochonia simplex, *Smith.*
Siphonia Kœnigi, *Mant.*
Seliscothon planus *Phil.*
Stichophyma tumidum, *Hinde.*
Verruculina plicata, *Hinde.*
„ Reussi, *M'Coy.*

A calcareous sponge, *Pharetrospongia Strahani*, Sollas, also occurs not unfrequently, but it is not confined to the Upper Chalk.

The small organic bodies known as *Porosphæra* have been regarded as Hydrozoa, but Dr. Hinde has shown that they belong to the Sponges. The spherical *Porosphæra globularis* is one of the commonest fossils of the Upper Chalk, and is to be found in every part of it. It varies in size from that of a pea to that of a walnut. Two other species (*P. urceolata* and *P. Woodwardi*) of a very different shape also occur.

THE SPECIES OF MICRASTER.

It has long been known that species of the genus *Micraster* are abundant in the lower part of the Upper Chalk, and it has been found that they present a succession of species and varieties which are of great use in determining the limits of the zones and the horizon of isolated inland exposures. Consequently it has become necessary for all students of the Upper Chalk to make themselves acquainted with the characters of the principal forms, and hence it seems desirable to give brief diagnoses of these before entering on the stratigraphical details, in which they will be so frequently mentioned. I have, therefore, prepared such condensed diagnoses from the detailed descriptions published by Dr. A. W. Rowe, in his "Analysis of the Genus *Micraster*."*

Micraster corbovis, *Forbes*.—This species varies greatly in size, the length varying from a small form of 31mm., to a large one of 81mm. The test is very thin, contrasting in this

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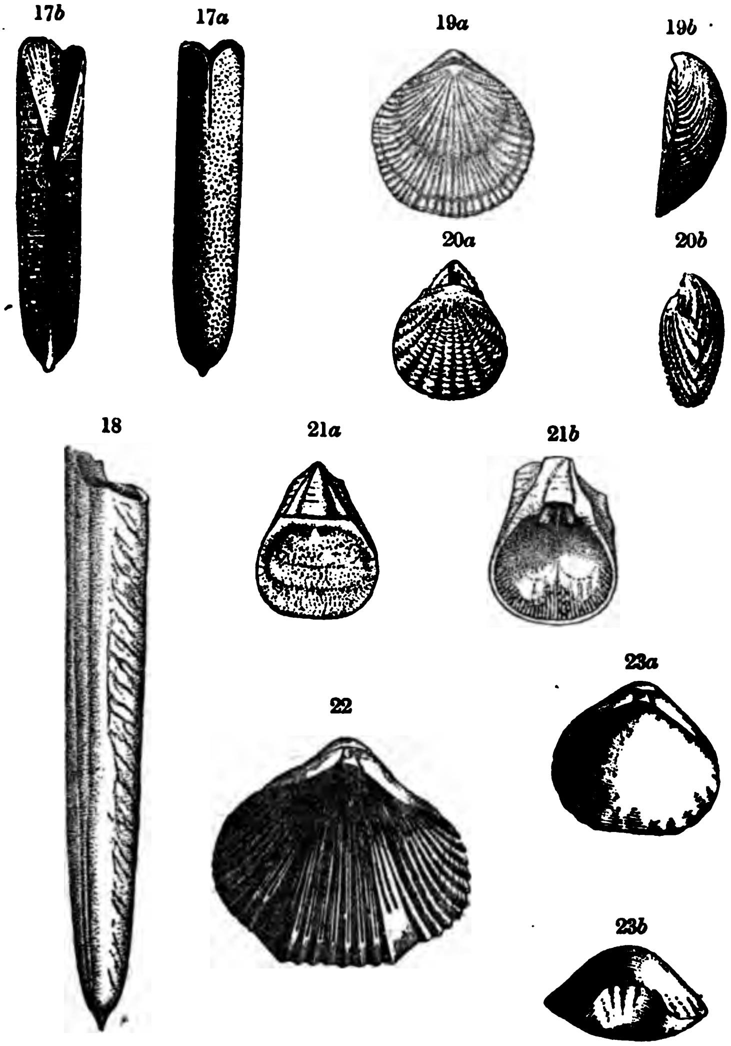
* Quart. Journ. Geol. Soc., lv., p. 494 (1899).



Upper Chalk Fossils (Higher Zones).

Fig. 17.—Actinocamax quadratus, *Blainv.* (two-thirds of nat. size). *a*, ventral view; *b*, section to show alveolar cavity.

„ 18.—Belemnitella mucronata, *Sow.* (two-thirds of nat. size), side view.

„ 19.—Terebratulina gracilis, *Schloth.* (twice nat. size). *a*, dorsal view; *b*, side view.

„ 20.—Terebratulina Gisei, *Hag.* (twice nat. size). *a*, dorsal view; *b*, side view.

„ 21.—Thecidium vermiculare, *Schloth.*, upper and lower valves (twice nat. size).

„ 22.—Rhynchonella plicatilis, var. octoplicata, *Sow.* (nat. size), dorsal view.

„ 23.—Rhynchonella limbata, *Schloth.* (nat. size), dorsal and front views.

respect with all other Micrasters. In shape it is generally an elongate oval, and its upper surface is generally depressed so that its height is relatively small, that of large specimens varying only from 44 to 49mm.

The paired ambulacra are deeply impressed with a smooth interporiferous area, and the pores are elongate, those of the outer row being tear-shaped. The subanal fasciole is feebly marked.

On the under surface the mouth is set far in from the anterior margin, the peristome is a smooth flat ring, and the labrum feebly developed. The labral plate is broad where it joins the plastron and tapers to the labrum, bearing only one or two tubercles near the tip. The periplastronal area is a broad band which is either smooth or very faintly granular, again contrasting with the strongly granular area of other Micrasters.

Micraster corbovis occurs in the *Terebratulina* beds of the Middle Chalk, but is commoner in the *Holaster planus* zone, and has not been found at any higher horizon.

Micraster Leskei, *Desm.*—This species has been widely known on the Continent as *M. breviporus*, Ag. (*see* Fig. 6). In size it is rather small, averaging about 34mm. in length, but the test is thick. The paired ambulacra are deep, with smooth interporiferal areas (*see* Fig. 29*a*), and the pores are elongate. The upper surface is depressed and the subanal fasciole is distinct, but narrow.

Beneath, the mouth is distant from the border, and its labrum is smooth as in *M. corbovis*. The labral plate is also of similar shape (*see* Fig. 30*a*), and seldom bears more than six primary tubercles, sometimes only two or three. The periplastronal area is always finely granulated.

M. Leskei is specially characteristic of the zone of *Holaster planus*, and is not found above that zone, though it ranges downward into the Middle Chalk. There is, moreover, a passage-form between *M. Leskei* and *M. præcursor* which appears to be restricted to the zone of *H. planus*; this differs in several points, having sutured interporiferal areas and more tubercles on the labral plate. A passage-form between *M. Leskei* and *M. corbovis* also exists.

Micraster præcursor, *Rowe.*—Dr. Rowe calls this form a group rather than a species, but he admits that "if it be right to preserve *M. coranguinum* as a species, it is equally right to use *M. præcursor* in the same sense." It is in fact a plastic species and varies in its details according to the zone in which it occurs.

This form is variable in size, but its average length is about 50mm. and its breadth is generally about 3mm. less than the length. It has the common low zonal characters of a depressed upper surface, and deeply impressed ambulacra, but the interporiferal area is never smooth; those in the zone of *H. planus* have the plates of this area merely "sutured," but those from

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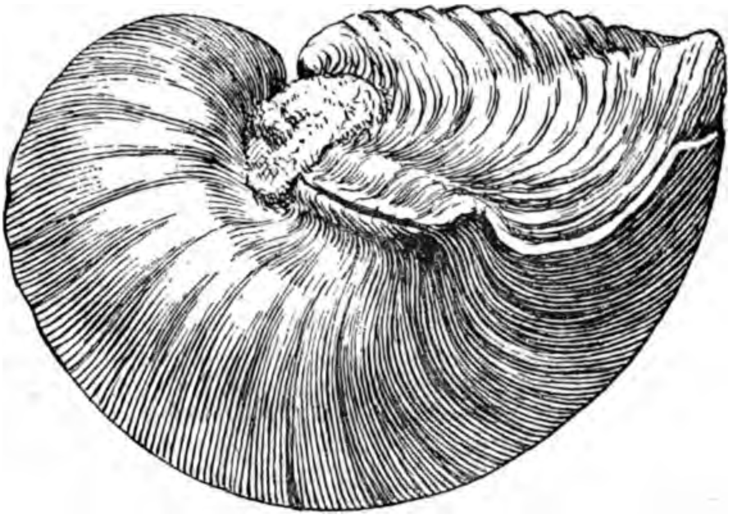

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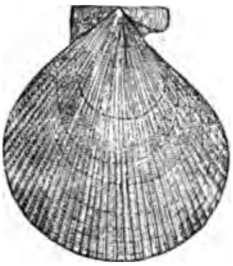

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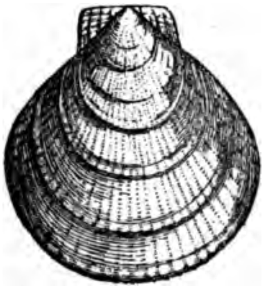

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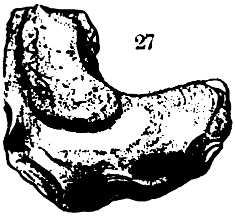

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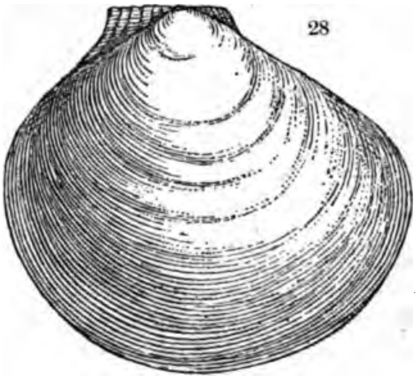

UPPER CHALK FOSSILS (HIGHER ZONES).

FIG. 24.—Inoceramus involutus, *Sow.* (nat. size).
„ **25.**—Pecten (Chlamys) cretosus, *Defr.* (nat. size).
„ **26.**—Pecten (Chlamys) mantellianus, *d'Orb.* (= P. concentricus, *S. Woodward*), (nat. size).
„ **27.**—Ostrea lunata, *Lam.* (nat. size).
„ **28.**—Lima Hoperi, *Sow.* (nat. size).

higher zones have them strongly inflated, and more or less divided from one another along the median line (*see* Fig. 29*b*). The subanal fasciole is well marked.

On the lower surface the mouth still remains distant from the border; but the labrum shows a gradual change; for only its central part or " tip " is ever smooth; in the zone of *Hol. planus* this is always smooth, in that of *M. cortestudinarium*, about 80 per cent. have a smooth tip, but in the zone of *M. coranguinum* it is wholly granular. The labral plate is subtriangular in the two lower zones, becoming narrower in the zone of *M. coranguinum*, bearing on an average from 10 to 12 tubercles (*see* Fig. 30*b*). The periplastronal area also shows a progressive degree of granulation in passing upward from the *H. planus* zone.

This species commences in the zone of *H. planus*, and ranges into that of *M. coranguinum*, dying out within the lower third of that zone (at any rate in the South of England).

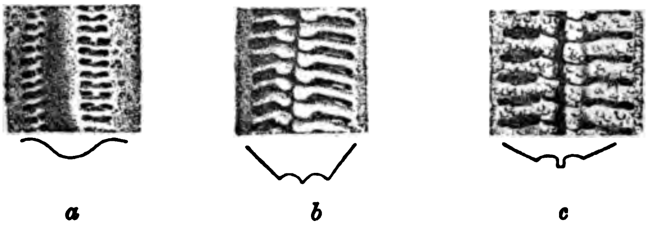

FIG. 29. After Rowe.—Magnified views of a portion of the ambulacral area of—

a. Micraster Leskei, with smooth area ;
b. „ præcursor, with inflated area ;
c. „ coranguinum, with divided area.

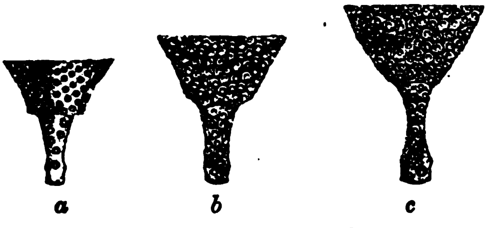

FIG. 30. After Rowe.—Views of the labral plate and part of the plastron of *a.* Micraster Leskei; *b.* M. præcursor; *c.* M. coranguinum.

Micraster cortestudinarium, *Goldf.*—This form is not sufficiently distinct to be regarded as a species comparable with the others. It has all the characters of *M. præcursor*, except that its breadth is as great as its length. It has no other special features and is, in fact, merely a broad variety of *M. præcursor* or of the *M. præcursor* group; having the same range, and exhibiting just the same variations according to the horizon at which it occurs as the members of that group do. In the zone of *M. coranguinum* it gradually loses its low zonal characters and passes into the broad variety of *M. coranguinum*.

Micraster coranguinum, *Leske.*—This species varies much in size and shape, but differs from *M. præcursor* in the following points. The posterior part of the test is always high, and its upper surface is raised into a median ridge or *carina* (*see* Fig. 10*b*). The paired ambulacra are shallow, while the anteal sulcus is generally deep. The interporiferous area is traversed by a furrow which divides one half from the other half, and the whole surface of the umbulacrum is strongly granulated (*see* Fig. 29*c*).

The subanal fasciole is broad and clear. The mouth is situate near the border; its labrum is always strongly granulated and the labral plate is narrow, expanding more or less at each end, and is generally covered with tubercles (Fig. 30*c*). The periplastronal area is covered with large prominent granules so as to present a very rough and almost tubercular surface.

M. coranguinum is often abundant in the zone to which it gives its name, and also in the zone *Marsupites*, but becomes rarer in the higher zones. The broad variety *latior* bears the same relation to it as *M cortestudinarium* does to *M. præcursor.*

CHAPTER III.

THE UPPER CHALK IN SUSSEX.

1.—THE CLIFFS FROM BEACHY HEAD TO BRIGHTON.

GENERAL DESCRIPTION.

The earliest description of the Upper Chalk in these cliffs is that by Dr. Mantell in his Geology of Sussex (1822), but is only a general account of the "Chalk with flints"; as, however, there are very few flints in Sussex below the zone of *Holaster planus*, his Upper Chalk is practically coextensive with that which is so regarded in this memoir.

A more careful description of the part between Seaford and Beachy Head, with a horizontal section, was given by Mr. Whitaker in 1871.* In this he indicates the flexure at Seaford, and correlates the Chalk of the Sussex coast with that of the Kentish coast as described by Mr. W. Phillips. His "Chalk with flints and nodular layers" includes the parts now known as the zones of *Holaster planus* and *Micraster cortestudinarium*, the rest of the Upper Chalk being called simply "chalk with flints." He was uncertain whether the Margate Chalk was represented in Sussex.

In 1876 Prof. Ch. Barrois published a detailed account of the chalk which forms the Sussex cliffs,† recognising in them the zones with which he was familiar in France. His description was illustrated by a section on the scale of about two inches to a mile.

Professor Barrois' work was a great advance on anything that had been written about the Chalk of England prior to its date of publication (1876), and his description of the beds seen in the coast section is very good and accurate, but the correct allocation of the beds to their several zones cannot always be accomplished on the basis of a day's collecting of the fossils. It will be seen in the sequel that I found reason to suspect that Professor Barrois had assigned too great a thickness to the *Marsupites* zone, and too little to that of *M. coranguinum*. This view has been confirmed by the more prolonged researches of Dr. A. W. Rowe and Mr. C. D. Sherborn in 1898 and 1899.

Since this chapter was first written these researches have been published.‡ I have availed myself of Dr. Rowe's observations

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* On the Chalk of the Cliffs from Seaford to Eastbourne, Geol. Mag. Vol. viii. p. 198.

† Recherches sur le Terr. Crét. Sup., pp. 14-27.

‡ See Proc. Geol. Assoc., Vol. xvi., p. 289 (1900), "The Zones of the White Chalk of the English Coast," by Dr A. W. Rowe. with sections by C. D. Sherborn.

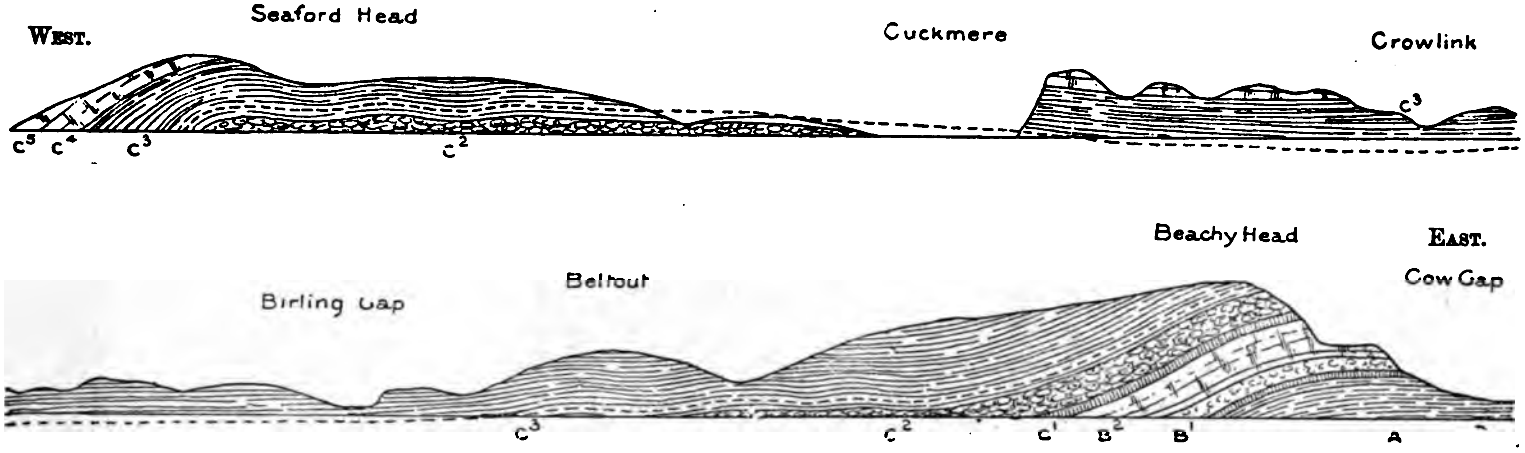

FIG. 31.—Section along Coast from Seaford Head to Beachy Head (after Messrs. Rowe and Sherborn).

Horizontal Scale, two inches to a mile. Vertical Scale, 800 feet to an inch.

C^5. Zone of *Actinocamax quadratus.*
C^4. Zone of *Marsupites.*
C^3. Zone of *Micraster coranguinum.*
C^2. Zone of *Micr. cortestudinarium.*
C^1. Zone of *Holaster planus.*
B^2. Zone of *Terebratulina.*
B^1. Zone of *Rhynchonella Cuvieri.*
A. Lower Chalk.

and have re-written the larger portion of the chapter. Mr. W. Hill examined the chalk of Beachy Head in 1896 and 1897, and the description of the lower zones there seen is from his notes. The section (Fig. 31) is reduced from that given by Messrs. Rowe and Sherborne.

The thicknesses of the several zones now recognised in this coast section are stated by Dr. Rowe as follows:—

		Feet.
Zone of *Actinocamax quadratus*	about	170
Zone of *Marsupites testudinarius*	,,	78
Zone of *Micraster coranguinum*	,,	242
Zone of *Micraster cortestudinarium*	,,	109
Zone of *Holaster planus*	,,	48
		647

STRATIGRAPHICAL DETAILS.

Zone of Holaster planus.

The zone of *Hol. planus* forms part of Beachy Head, the beds dipping westward, and it comes down to the shoreline at a point about a quarter of a mile west of the west corner of the place called Gun Gardens on the six-inch Ordnance map.

Although there is no hard and fast line of demarcation between the chalk of this zone and that of the underlying *Terebratulina* zone, yet there is no difficulty in recognising the junction of the two zones; for with the exception of a few scattered flint nodules at the top of the lower zone, there are practically no flints until the zone of *Holaster planus* is reached.

The character of the chalk changes at the same time from a homogeneous blocky white chalk to chalk containing frequent courses of hard yellowish-grey lumps. The following description is from notes taken by Mr. W. Hill in 1897.

The zone of *Holaster planus* consists throughout of more or less nodular chalk, which gives it a rough appearance in the cliff, In the lower part there are frequent courses, about three feet apart. of hard semicrystalline lumps, separated from one another by soft mealy chalk, but the greater part of these layers consists of the hard chalk; each such course passes down into less hard, but still nodular or lumpy chalk. The upper surface of these courses is usually well defined, not only by the rougher and more nodular character of the rock, but also by the numerous small flint-nodules which are thickly scattered through the upper twelve or eighteen inches of each course, and appear as definite flinty layers when the cliff is viewed from a little distance.

There is no bed which consists throughout of hard compact limestone like that known as Chalk Rock, nor could he find any bed that contained the characteristic fossils of this "Rock"; indeed, at this place both Cephalopoda and Gasteropoda seem to be so scarce that not a single specimen was seen.* A few fragments of brown phosphatic matter may be seen here and there, but these are by no means common.

In the upper part of the zone the hard courses are less well-developed, and the highest ten or eleven feet consists of chalk of a more uniform character, *i.e.*—somewhat rough and nodular throughout and without any specially hard or nodular layers. About eleven feet down there is, however, a conspicuous nodular layer, consisting of the usual hard yellowish nodules embedded in softer mealy chalk. The following is the descending succession of beds :—

	Feet.
Chalk, somewhat nodular, with scattered flints	11
Course of hard yellowish nodular chalk	1
Whitish chalk, rough and lumpy, with irregular layers of scattered flints at intervals of about 3 feet	25
Cream-coloured chalk in courses about 3 feet thick, each having a hard nodular bed, with flints, at the top	12
	49

The zone contains many fossils throughout, and there is no difficulty in finding *Holaster planus, Echinocorys scutatus, Micraster Leskei, M. præcursor, Cidaris clavigera, Rhynchonella reedensis,* and *Rh. plicatilis ;* in the topmost eleven feet Micrasters of the *præcursor* and *cortestudinarium* types predominate, and we were inclined to regard this as the base of the *M. cortestudinarium* zone, but in deference to the result of Dr. Rowe's careful collecting we accept his limit of the zone.

Dr. Rowe says—" In this section we relied entirely upon *Micraster* for fixing an upper limit to the zone, mapping out the chalk foot by foot, and taking the Micrasters obtained from each foot of chalk to the water edge, and there cleaning and examining them before collecting from the next foot of chalk. We found that the essential features of the test gave us a limit-line which coincided with the cessation of *Holaster planus, Micraster corbovis, M Leskei, Pentacrinus,* and other guide-fossils of this zone." (Loc. cit. p. 326.) He fixes this limit-plane as thirty feet below a marked layer of marl which forms an open band in the cliff, and runs through the first cave west of Gun Gardens. He gives forty-eight feet as the total thickness of the zone, which agrees closely with Mr. Hill's measurements above given.

Zone of Micraster cortestudinarium.

The chalk last mentioned is succeeded by chalk which still presents some nodular layers, but these are at a greater distance apart and alternate with thicker courses of soft white chalk which contain many flints, both scattered and in layers, at irregular intervals. There are also several continuous layers of flint, which is an unusual feature in this zone.

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* This is corroborated by Dr. Rowe, who did not succeed in finding any specimens of either class except *Pleurotomaria perspectiva.*

As Mr. Hill was not able to examine this part of the section so thoroughly as Messrs. Rowe and Sherborne have since done, I gladly avail myself of the measured section which they have published, (loc. cit. p. 327), and adopt their limit for the zone, which is taken at a rather lower horizon than that indicated by Professor Barrois. The measurements are as follow in ascending order, the beds still continuing to come in along the cliff base with the westerly dip:—

	Feet.
From top of *H. planus* zone to an open marl-band - -	30
From open marl-band to first tabular flint-layer - - -	26
From first tabular flint to second tabular flint-layer - -	20
From second tabular flint-layer to base of a thick layer of scattered flints - - - - - - - - - - - -	13
From base of layer of scattered flints to third tabular flint-layer - - - - - - - - - - - - -	9
From third tabular flint to fourth tabular flint-layer - -	11½
	109½

"This last-mentioned tabular flint-line will be called the *M. cortestudinarium*-tabular, as it approximately marks the zoological break between this zone and the one above it." With respect to the fossils of the zone, Dr. Rowe writes thus: "*Micraster* is our only reliable guide, and the essential features of the test, which were so helpful at Dover, are equally reliable and constant here. The proportion of the broad *Micraster cortestudinarium* forms is rather larger than at Dover, and the percentage of occurrence of the 'sub-divided' ambulacral area is also larger than at Dover, and is quite characteristic of this zone. *Echinocorys vulgaris* var. *gibbus* is common. . . . . The spines of *Cidaris clavigera* are, if anything, in greater profusion than in the zone below, and while *Cidaris serrifera* is still a characteristic form, it is not so abundant as the former. . . . . *Holaster placenta* is common, and small examples of this fossil have been mistaken for *Holaster planus*. Bryozoa are abundant. . . . . No Gasteropods have been found. . . . . Sponges are poor in this zone at Beachy Head, with the exception of a small form of *Pharetrospongia Strahani*, which is very abundant both in this zone and in the base of the *M. coranguinum* zone."

As Prof. Barrois pointed out, the flints in this zone are generally more or less carious or cavernous, the hollows having doubtless been originally filled by sponges, but being now occupied by soft, powdery chalk, which contains sponge-spicules, some Bryozoa, and silicified Foraminifera. They often have a fairly thick crust which is sometimes white and sometimes pinkish.

The beds comprised in the zone of *M. cortestudinarium* pass beneath the chalk which forms the cliffs of Berling and Crowlink, but they are brought up again by the anticline of Cuckmere Haven (see Fig. 31), and, according to Dr. Rowe, the low cliffs west of the haven show a thickness of 80 feet of this zone. Here, however, it is apparently less nodular, and does not weather out into rugged knobs, as usual elsewhere; moreover, "there is no *M. cortestudinarium* tabular, as at Beachy Head, but much in the same position we find a thin closed marl-band which approximately marks the junction between this zone and that of *M. coranguinum.*" (*Op. cit.* p. 336.)

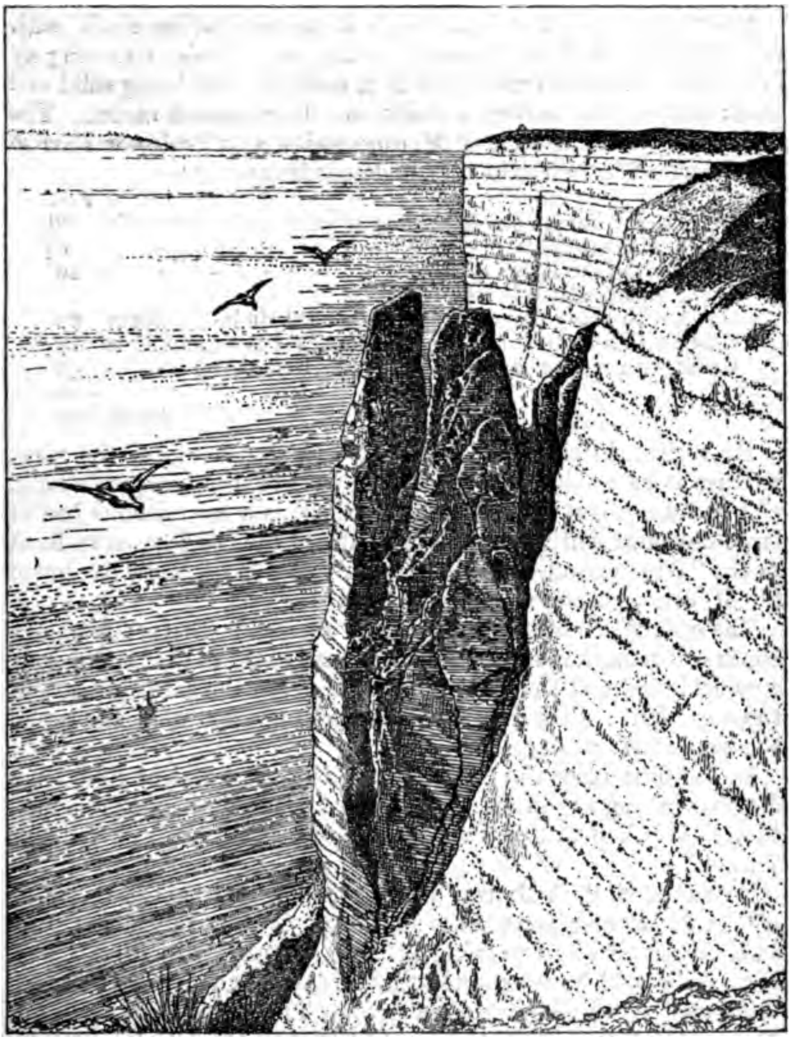

FIG. 32.—View of the upper part of the cliff at Beachy Head, from a photograph by the Rev. W. R. Andrews. (Zones of *M. cortestudinarium* and *M. coranguinum.*)

Zone of Micraster coranguinum.

Above the continuous flint layer, which Dr. Rowe calls the "*cortestudinarium* tabular," there are two or three well-marked yellow nodular bands, and, according to Professor Barrois, the chalk containing these bands is about fourteen feet thick (four metres). Lithologically they are a continuation of the *M. cortestudinarium* chalk, but Dr. Rowe finds that "zoologically they must be included in the zone of *M. coranguinum*, as the fossils are scanty and belong to the higher zone.

Above these nodular beds there is massive white chalk with regular layers of flints; these, according to Barrois, occurring at intervals of from 18 inches to 3 feet, most of them being solid and black inside, but having a thick zoned or banded cortex. The beds assigned to the zone of *M. coranguinum* by Professor Barrois are described by him as follows, in descending order :—

	Feet.
Indurated yellowish bed containing greenish nodules of chalk	0½
Chalk without flints - - - - - - - - - -	6½
Chalk with four layers of flints - - - - - - -	16
Layer of large flat pale-coloured flints.	
Chalk with many flints which have banded rinds - about	26
Chalk with layers of tabular flint and bands of cavernous flints	16
Chalk with regular layers of flints (described above) - -	48
About	115

He regarded the yellowish nodule bed as the top of the zone, because it resembled the bed at the base of the Margate Chalk, and because about 22 feet below it there is a conspicuous bed of large flattened lenticular flints resembling the bed known in Kent as the "3-inch band," which occurs about 21 feet below the top of the *M. coranguinum* zone (see p. 143).

The occurrence of two similar beds at similar distance from one another is remarkable, but we are inclined to think that it is merely a coincidence, and that they do not occur on the same horizon as those in Kent; that they are in fact a long way below the top of the zone of *M. coranguinum*.

In the first place the continuity of the same bed of flint for a distance of more than 60 miles would be a very remarkable fact, though it is known that such beds do sometimes continue for 6 or 7 miles.

Secondly, if Prof. Barrois' assumption is correct, the thickness of the *M. coranguinum* zone in Sussex is very much less than in Kent, his own figures being 115 feet, as compared with 231 feet. Now we should have expected that, if there was any difference in thickness, it would have been greater in Sussex than in Kent, because the Upper Chalk appears to thicken in a westerly direction, and is certainly thicker in the Isle of Wight than it is in Sussex.

Thirdly, the chalk above the yellow band in Sussex has not yielded any trace of *Marsupites*; neither Prof. Barrois nor Mr.

Rhodes, who was specially instructed to search for them, succeeded in finding a single plate.

Fourthly, the characters of this chalk are not like those of the Margate Chalk, which contains very few flints, while this contains frequent layers of black flints for nearly 100 feet above the nodular band.

Taking all these facts into consideration, we are inclined to believe that all the beds with frequent layers of flints, which overlie the yellow nodular bed, should be included in the zone of *Micraster coranguinum.* If these beds are 92 feet thick, as estimated by Barrois, the total thickness of the zone will then be about 212 feet, which is not far from its thickness in Kent. It is true that there is no nodule bed or specially marked plane of division at this horizon, but we do not believe that zones are always separated by physical breaks, and we imagine that the expectation of finding a *banc limite* may easily lead the observer astray.

The above was written before Dr. Rowe commenced his examination of the Sussex coast section, and it is satisfactory to find that the view above expressed is entirely corroborated by his careful collecting of the fossils. He has moreover succeeded in discovering plates of both *Marsupites* and *Uintacrinus*, and has been able to fix the upper limit of the zone of *M. coranguinum* in a much more satisfactory manner—namely, by the evidence of the fossils carefully collected from each foot of the chalk near the critical horizon. This, however, can only be done between Cuckmere and Seaford, for in the Birling and Crowlink cliffs the junction is far out of reach. Dr. Rowe terms the beds indicated by Professor Barrois "the spurious tabular and sponge bed," and remarks that they are plainly visible about half-way up the cliff at Birling Gap:—"These bands dip to the west, until at Crowlink Coastguard Station the flint line is level with the beach; but from that point the bands steadily rise again, and very soon the sponge bed dies out. In these lower cliffs we have a better chance of studying the beds in the upper part of the cliff, and we notice that . . . . the flint lines space out [are wider apart] in the upper third of the cliff. If we view the [Seven] 'Sisters' from either side we notice that the tint of the chalk in the highest 'Sisters' is of a greyer colour, and that this discolouration corresponds with the upper of two strong nodular flint lines, 9 feet apart, and that these two flint lines generally pass out of the cliff in the hollows between the highest 'Sisters.' The importance of this observation will be seen when we come to trace the same two flint lines in Seaford Head, for we find that the *Uintacrinus* Chalk is there apparently limited below by the upper of these two flint lines."

"In 1898 we found at the summit of the first and fourth 'Sisters' (counting from Cuckmere) *Uintacrinus*, *Bourgueticrinus* (with nipple-shaped head), and *Echinocorys vulgaris, var. pyramidatus.* . . . . . These fossils were obtained in bare patches, where the turf had been denuded at the cliff edge." Afterwards a Marsupite plate was found on the first "Sister." (*Op. cit.*, pp. 330, 331.)

In the cliffs west of Cuckmere Haven the *M. cortestudinarium* zone again rises above the shore line, as already stated, and as the beds curve over to dip steeply westward in Seaford Head the whole of the *M. coranguinum* zone is here exposed in an easily accessible manner, and is found to be 242 feet thick. In this short distance, however, several changes seem to have taken place in the lithology of the beds, for, according to Dr. Rowe, not only has the sponge bed seen at Birling and Crowlink disappeared, but the "spurious tabular" flint has also thinned out. He found, however, that another conspicuous layer of flint, which he calls the "strong *M. coranguinum* tabular," is continuous all the way from Beachy Head to Seaford Head; this occurs about 60 feet above the base of the zone.

Here I would remark that although Prof. Barrois proves to be mistaken in the limits which he assigned to the several zones in this particular section, yet he correctly recognised the zones which enter into the chalk of Seaford Head, and we must remember that his zone of *Marsupites* included that which has since been separated as the zone of *Actinocamax quadratus.* It is in fact wonderful that Professor Barrois could have accomplished so much excellent work in the few months which he was able to give to it, and I desire to endorse Dr. Rowe's appreciation of Professor Barrois' pioneer researches.

Zone of Marsupites testudinarius.

Part of the chalk referred to this zone by Professor Barrois is described by him as "chalk which is almost devoid of flints," and in this he found *Actinocamax Merceyi.* This band is evidently comparable to some part of the Margate chalk, but until Dr. Rowe searched the beds in his careful and methodical manner no one had been able to find any trace of *Marsupites* or *Uintacrinus*, and consequently the zone remained without definition. What follows, therefore, is based upon the account given by Dr. Rowe.

In the section west of the Cuckmere he notes the existence of an oblique fissure, out of which a cave has been excavated, and that the junction of the *M. cortestudinarium* and *M. coranguinum* zones occurs at this cave. "Passing a little further west we trace the dip of the strong *M. coranguinum* tabular to the shore below the west side of the *Castrum.* Still passing westward, we reach the point where two strong nodular flint-lines sink to the shore. These are clearly the same two flint-lines, 9 feet apart, which we saw intersecting the bases of the highest of the 'Sisters,' so it is probable that we are nearing the junction with the *Marsupites* chalk." His search resulted in finding *Uintacrinus* at once above the upper of these flint-layers, but none below it, and accordingly he takes this layer of flints as the lower limit of the *Marsupites* zone.

His first search for *Marsupites* in 1898 was unsuccessful, but a more determined search in 1899 resulted in the discovery of *Marsupites* plates through a thickness of over 48 feet, these plates commencing to occur 28 feet 9 inches above the flint-bed. Thus he proved the zone to consist of two parts, a lower, in which *Uintacrinus* prevails, and a higher, in which *Marsupites* only is found. As will be seen on a later page, Dr. Rowe has found that the same sub-divisions exist in the Isle of Thanet.

The complete succession seen in the cliffs between Cuckmere Haven and Seaford may be given in this place. The beds here were measured by Dr. Rowe and Mr. C. D. Sherborn, and are stated by the former as follows:—

		Ft.	in.
Zone of *Micraster cortestudinarium.*	From the lowest part of *M. cortestudinarium* zone to the oblique fissure-cave where the closed marl-band divides this zone from that of *M. coranguinum* - - - - about	80	0
Zone of *Micraster coranguinum.*	From marl-band at oblique fissure-cave to place where the strong *M. coranguinum*-tabular sinks to the shore under the castrum - -	62	0
	From spot above mentioned to where the upper of two strong nodular flint-layers, 9 feet apart, sinks to the shore - - - - - - -	180	0
Zone of *Marsupites.*	From the upper of two strong flint-layers to point where the last *Uintacrinus*-plate and the first *Marsupites*-plate were found - - -	28	9
	From spot where the last *Marsupites*-plate was found to the upper of two marl-bands 470 feet from stone groyne - - - - -	49	9
Zone of *A. quadratus.*	From upper of two marl-bands to top of the *A. quadratus* chalk at west end of Seaford Head about	170	0
	Total	569	6

It should be pointed out, however, that in this tabular view Dr. Rowe includes the 20 feet of chalk which forms the transition band between the zone of *Marsupites* and that of *Act. quadratus* in the latter, though on p. 338 he expressly groups it with the former. If this is deducted from the thickness of the *A. quadratus* zone, only 150 feet is left for the latter at this place, and the thickness of the *Marsupites* zone will amount to about 98 feet.*

In the cliffs between Newhaven and Brighton the beds undulate slightly, and Dr. Rowe found that the top of the *Marsupites* zone was exposed at the base of the cliffs west of Old Nore Point and in the shore-reefs of the eastern part of Friars Bay.

The zone again rises from the shore between Ovingdean and Roedean, and the following indications are given by Dr. Rowe: "Passing westward over the two stone groynes (at the Pumping

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* I am informed by Dr. Rowe that these figures are correct, and should have been so printed in the table above quoted.

Station) we find an open marl-band rising from the shore . . . this marl-band forms the top of a wrought cave opposite the fifth electric standard-pole west of the groynes." Below this he found *Marsupites*-plates, above it no *Marsupites*, and for a certain space no *Offaster pillula*, there being a transition band, just as at Seaford Head. West of this, below Roedean, *Marsupites*-plates are abundant, for the beds continue to rise westward, and 58 feet of this zone can be measured at the Brighton end of the cliff. Finally, the *Uintacrinus* band comes up in the reefs, its existence, strongly suspected by Dr. Rowe, having been proved by Mr. W. MacPherson, who found a plate on the reef facing the Elephant-bed.

Of the chalk composing this zone near Brighton Dr. Rowe writes as follows:—"The chalk is soft and marly, with nodular and tabular flint-bands and marl-seams. No one could distinguish this chalk from that of the zone above, and the only difference is that the flints have a thin white cortex instead of a pink one. Even this distinction fails at certain places in the section. . . . There is no lithological break to divide this zone from that of *Actinocamax quadratus*."

It will be seen, therefore, that here the chalk of the *Marsupites* zone is by no means flintless, and in this respect differs greatly from the well-known Margate Chalk.

Zone of Actinocamax quadratus.

This zone includes all the higher part of the chalk which Professor Barrois referred to his zone of *Marsupites*.

The most complete exposure of it is in the western part of Seaford cliff, where a dip of 12 to 15 deg. brings in a great thickness of beds within a very short distance. Better opportunities of examining its lower beds and of collecting fossils are to be found in the long range of cliffs which extend from Newhaven to Brighton, for these are composed almost entirely of this zone from Newhaven westward for a distance of 6½ miles.

The chalk in the western part of Seaford cliff is described by Professor Barrois as containing many flints in layers about 6 or 7 feet apart, and these layers are not composed of single flints in line, but of many flints scattered irregularly through some 12 inches of chalk. The flints are black inside and not banded, smooth and regular in outline, and round or somewhat flattened in shape. He estimated the total thickness of this chalk at Seaford to be 40 mètres (130 feet), but by Dr. Rowe's measurement it is 150 feet (see page 37).

Dr. Rowe says, "The zone is characterised by a rather soft white chalk, greyish in places from admixture with marl, but often of a yellow colour from diffused staining with iron. Marl-bands, which often weather out as open seams, are common; so are tabular and nodular flint-bands, but the latter never occur with the regularity of those in the zone of *Micraster coranguinum*. We know of no chalk so full of tabular flint as this, and oblique fissures in the chalk are frequently in-filled with thin layers of flint." (*Op. cit.*, p. 340.)

Dr. Rowe does not give any particulars of the beds of this zone, either at Seaford Head or at Newhaven, and neither Mr. Hill nor I have been able to examine these sections. Professor Barrois' Newhaven section is the only one yet available, and this we give below, his thicknesses being altered to accord with the real height of the cliff, which is less than he supposed:—

	Feet.
Chalk with layers of flints at intervals, grey or black inside and some of them large - - - - - - about	25
Chalk with few flints, but some thin tabular layers. *Offaster pillula*, *Cyphosoma Kœnigi*, *Magas* and other fossils; about	50
Chalk in beds about 6 feet thick, separated by seams of marl; black flints of rounded shape occur, both scattered and in layers. *Inoceramus involutus*, *Offaster pillula* and *Echinocorys scutatus* - - - - - - - - about	35
	110

When collecting from these localities Mr. J. Rhodes observed that about 60 feet below the highest chalk in Seaford Head there was a bed in which *Offaster pillula* was very abundant, and that a similar bed occurred near the bottom of Newhaven cliff. At Newhaven the beds are nearly horizontal, so there must be a quick recovery from the steep inclination which they show in Seaford Head. Whether they are re-curved or faulted we have no means of knowing.

From Dr. Rowe's account we learn that the beds continue to be horizontal from Newhaven to Old Nore Point, where they begin to rise to the west, and a thin layer of tabular flint emerges from the shore. It is below this tabular layer that the top of the *Marsupites* zone comes up for a short distance. "The rise in the beds is not maintained, as there is a series of faults which brings the tabular to the shore again in the centre of [Friars] Bay."

Below Portobello the beds are again nearly horizontal, and from the chalk with nodular flints here accessible Mr. Rhodes obtained the following fossils:—

Actinocamax quadratus.
Rhynchonella plicatilis.
Bourgueticrinus ellipticus.
Offaster pillula.
Echinocorys scutatus
Porosphæra globularis.

According to Professor Barrois' account (Recherches, p. 25), these lower beds sink below the beach near Rottingdean, and the overlying chalk, with continuous layers of flint, comes down to the level of the shore. From these beds he obtained *Actinocamax Merceyi* (= *A. granulatus*), *Inoceramus lingua*, *Plicatula sigillina*, and the gibbous variety of *Echinocorys scutatus*. He describes and figures three layers of "tabular" or continuous flint, which here and there branch into two and unite again, thus enclosing flattish, lenticular masses of chalk from 4 inches to 3½ feet in length. He also remarks that the highest of these flint-floors is covered by a layer of marl about 4 inches thick, and that the chalk which overlies this marl is somewhat nodular.

West of Rottingdean the beds begin to rise again; the base of the zone is soon brought up, and the underlying chalk, with *Marsupites*, comes into the cliff as already stated (see p. 37). Prof. Barrois states that the flint and marl-band rises from the foot of the cliff at Rottingdean till it reaches the cliff top at Roedean Gate, near the turnpike.

Dr. Rowe records the occurrence of *Am.* [*Haploceras*] *leptophyllus* in considerable numbers at and near the base of this zone all the way from Newhaven to Rottingdean. Many of them are very large, frequently 4 feet in diameter, and one was 5½ feet across. Besides the usual fossils of the zone, Bryozoa are abundant, especially in a layer near Rottingdean. Of these he mentions *Eschara Danaë*, *Vincularia santonensis*, *V. disparilis*, and a new species of *Cribrilina* as specially characteristic.

One point seems clear from the observations and careful collecting of fossils by Professor Barrois and Dr. Rowe, and that is that the highest chalk seen in the cliffs between Newhaven and Brighton belongs to the zone of *Act. quadratus*, and that there is no indication of the incoming of the higher zone of *Belemnitella mucronata*.

FOSSILS FROM THE UPPER CHALK OF THE SUSSEX CLIFFS.

The following list of fossils is based upon that published by Dr. Rowe in his recent paper above mentioned, for though many of the species had been obtained previously by the Survey collector. Mr. J. Rhodes, yet he had not worked along the whole section, and Dr. Rowe's list is much more complete. To those given by Dr. Rowe I have added a few supplementary species and zonal occurrences, which are indicated by letters, thus those found by Mr, Rhodes are indicated by the letter S, those recorded only by Professor Barrois are shown by the letter B, and those found by Mr. Maddock by the letter M. Many fossils have been obtained from the chalk of or near Brighton by the older collectors, but their zonal horizons being unknown, they could not be admitted into this list:—

	Zone of Holaster planus.	Zone of M. cortestudinarium.	Zone of M. coranguinum.	Zone of Marsupites.	Zone of Act. quadratus.
Pisces.					
Beryx radians? *Ag.* (Ctenothrissa)	x	x	x	x	x
Cimolichthys lewesiensis, *Leidy*	–	–	–	–	x
Corax falcatus, *Ag.*	–	x	x	x	x
„ pristodontus, *Ag.*	–	–	–	–	x
Enchodus lewesiensis, *Mant.*	–	–	x	x	x
Lamna appendiculata, *Ag.*	x	x	x	x	x
Macropoma Mantelli, *Ag.*	–	–	B	x	x
Oxyrhina Mantelli, *Ag.*	–	x	x	x	x
Ischyodus sp.	–	–	B	–	–
Ptychodus mammillaris, *Ag.*	M	x	–	–	–
Cephalopoda.					
Ammonites [Haploceras] leptophyllus *Sharpe*	–	–	–	x	x
Actinocamax granulatus, *Blainv.*	–	–	–	x	x
„ quadratus? *Defr.*	–	–	–	–	S
„ verus, *Miller*	–	–	–	x	–
Gasteropoda.					
Aporrhais sp.	–	–	–	x	–
Pleurotomaria perspectiva, *Mant.*	x	x	x	–	–
Lamellibranchiata.					
Caprotina sp.	–	–	B	–	–
Inoceramus Brongniarti, *Sow.*	x	–	–	–	–
„ Cuvieri, *Sow.*	x	x	x	x	x
„ digitatus, *Sow.*	–	B	B	–	–
„ involutus, *Sow.*	–	x	x	–	B
„ Lamarcki, *Sow.*	–	S	–	–	–
„ lingua, *Goldf.*	–	–	–	–	B
„ mytiloides?, *Sow.*	x	–	–	–	–
Lima granosa, *Goldf.*	–	–	x	x	–
„ Hoperi, *Sow.*	–	x	x	x	x
„ pectinata, *d'Orb.*	–	–	–	–	x
Ostrea alæformis, *S. Woodw.*	–	–	–	x	x
„ canaliculata, *Sow.*	x	x	x	x	x
„ hippopodium, *d'Orb.*	x	x	x	x	x
„ normaniana, *d'Orb.*	x	x	x	x	x
„ semiplana, *Sow.*	x	x	x	x	x
„ vesicularis, *Lam.*	x	x	x	x	x
„ wegmanniana, *d'Orb.*	–	–	–	x	x
Pecten (Chlamys) cretosus, *Defr.* (=nitidus)	x	x	x	x	x
„ sp.	–	–	–	–	S
„ (Neithea) Dutemplei, *d'Orb.*	–	–	–	–	x
„ „ quinquecostatus, *Sow.*	x	x	x	x	x
Plicatula sigillina, *S. Woodw.*	x	x	x	x	x
„ Barroisi, *Peron*	x	x	x	x	–

	Zone of Holaster planus.	Zone of M. cortestudinarium.	Zone of M. coranguinum.	Zone of Marsupites.	Zone of Act. quadratus.
Spondylus æqualis, *Héb.*	–	–	–	–	B
„ dutempleanus, *d'Orb.*	M	x	x	x	x
„ latus, *Sow.*	x	x	x	x	x
„ spinosus, *Sow.*	x	x	x	x	x
„ striatus ? *Sow.*	–	–	–	–	S
Teredo amphisbæna, *Goldf.*	–	x	x	x	x
Brachiopoda.					
Crania egnabergensis, *Retz.*	x	x	x	x	x
„ parisiensis, *Defr.*	–	x	x	x	x
Kingena lima, *Defr.*	–	–	x	x	–
Rhynchonella Cuvieri, *d'Orb.*	x	x	–	–	–
„ limbata, *Schloth.*	–	x	B	–	x
„ plicatilis, *Sow.*	x	–	S	x	x
„ „ var. octoplicata, *Sow.*	x	–	–	x	x
„ reedensis, *Eth.*	x	x	x	x	x
Terebratula carnea, *Sow.*	x	x	B	–	S
„ semiglobosa, *Sow.*	x	x	x	–	x
Terebratulina gracilis, *Schloth.*, var. lata, *Eth.*	x	–	–	–	–
„ Rowei, *Kitchin*	–	–	–	x	x
„ striata, *Wahl.*	x	x	x	x	x
Thecidium Wetherelli, *Morris*	–	–	x	x	x
Bryozoa.					
Alecto sp.	–	–	–	–	S
Cribrilina sp. nov.	–	–	–	–	x
Diastopora sp.	–	–	–	–	S
Entalophora pustulosa, *d Orb.*	–	–	–	–	S
„ ramosissima, *d Orb.*	–	–	–	–	S
„ sp.	–	S	S	–	–
Eschara Acis, *d'Orb.*	–	–	–	–	S
„ Aceste, *d'Orb.*	–	–	–	–	S
„ Danaë, *d Orb.*	–	x	–	–	–
„ sp.	–	–	S	–	–
Escharina inelegans, *Lonsd.*	–	–	S	–	S
Homœosolen ramulosus, *Lonsd.*	–	S	–	–	–
Micropora (Escharina) intricata, *Lonsd.*	–	x	–	–	–
Proboscina ramosa, *Edw.*	–	–	–	–	S
Reticulipora (Retecrisina) obliqua, *d'Orb.*	–	S	–	–	–
Semicystis rugosa, *d'Orb.*	–	x	–	–	–
Vincularia santonensis, *d'Orb.*	–	–	–	–	x
„ disparilis, *d'Orb.*	–	–	x	x	x
Crustacea.					
Enoploclytia Leachi, *Mant.*	x	–	x	x	x
Pollicipes glaber, *Roemer*	–	–	x	x	x
Scalpellum fossula, *Darw.*	–	x	x	x	x
„ maximum, *Sow.*	–	x	x	x	x

——	Zone of Holaster planus.	Zone of M. cortestudinarium.	Zone of coranguinum.	Zone of Marsupites.	Zone of Act. quadratus.
Annelida.					
Serpula ampullacea, *Sow.*	x	x	x	x	x
„ fluctuata, *Sow.*	x	x	x	x	x
„ granulata, *Sow.*	–	x	x	x	x
„ ilium, *Sow.*	x	x	x	x	x
„ plana, *S. Woodw.*	x	x	x	x	x
„ macropus, *Sow.*	x	x	x	x	x
„ plexus, *Sow.*	x	x	x	x	x
„ turbinella, *Sow.*	–	–	x	x	x
Echinodermata.					
Bourgueticrinus ellipticus, *Miller*	–	B	x	x	x
„ sp. nov.	–	–	–	x	x
Cidaris clavigera, *König*	x	x	x	x	x
„ hirudo, *Sorig.*	x	x	x	x	x
„ perornata, *Forbes*	x	x	x	–	–
„ sceptrifera, *Mant.*	x	x	x	x	x
„ serrifera, *Forbes*	x	x	x	–	–
Cyphosoma corollare, *Klein*	–	–	x	–	–
„ Kœnigi, *Mant.*	x	x	x	x	x
„ radiatum, *Sorig.*	x	x	x	–	x
„ spatuliferum, *Forbes*	–	–	x	–	–
Discoidea Dixoni, *Forbes*	x	–	–	–	–
Echinocorys scutatus, *Leske*, var. gibbus, *Lam.*	x	x	x	–	–
„ „ var. pyramidatus, *Portl.*	–	–	–	x	x
Epiaster gibbus, *Lam.*	–	–	x	–	–
Galerites albogalerus, *Leske*	–	x	x	x	–
Hemiaster minimus, *Ag.*	x	x	–	–	–
Holaster planus, *Mant.*	x	x	–	–	–
„ placenta, *Ag.*	x	x	x	x	x
Infulaster rostratus, *Forbes*	–	–	x	–	–
Marsupites testudinarius, *Schloth.*	–	–	–	x	–
Micraster coranguinum, *Leske*	–	–	x	x	x
„ corbovis, *Forbes*	x	–	–	–	–
„ cortestudinarium, *Goldf.*	x	x	x	–	–
„ glyphus, *Schlüt.*	–	–	–	–	B
„ Leskei, *Desm.*	x	–	–	–	–
„ præcursor, *Rowe*	x	x	x	–	–
Offaster pillula, *Lam.*	–	–	–	–	x
Ophiura sp.	–	–	–	–	x
Pentacrinus sp.	x	x	x	x	–
Salenia granulosa, *Forbes*	x	x	x	x	x
Actinozoa.					
Axogaster cretacea, *Lonsd.*	–	–	x	x	x
Cœlosmilia laxa, *E. and H.*	–	–	–	–	x
Epiphaxum auloporoides, *Lonsd.*	x	x	x	x	–
Parasmilia centralis, *Mant.*	x	x	x	x	x
„ Fittoni, *E. and H.*	–	–	–	x	x
„ granulata, *Duncan*	–	–	–	–	–

	Zone of Holaster planus.	Zone of M. cortestudinarium.	Zone of M. coranguinum.	Zone of Marsupites.	Zone of Act. quadratus.
Spongida.					
Camerospongia capitata, *T. Smith*	M	–	–	–	–
„ subrotunda, *Mant.*	M	–	–	–	–
Cephalites catenifer, *T. Smith*	M	–	–	–	–
„ guttatus, *T. Smith*	M	–	–	–	–
Cliona cretacea, *Portl.*	x	x	x	x	x
Coscinopora infundibuliformis, *Goldf.*	–	x	x	x	x
Craticularia Fittoni, *Mant.*	x	–	–	–	–
Doryderma ramosum, *Mant.*	x	x	x	x	x
Elasmostoma scitulum, *Hinde*	–	x	–	–	–
Guettardia stellata, *Mich.*	x	x	x	x	x
Heterostinia obliqua, *Benett*	x	x	x	x	x
Leptophragma Murchisoni, *Goldf.*	–	x	x	x	x
Pachinion scriptum, *Rœm.*	–	x	x	x	–
Pholidocladia ramosa, *Hinde*	–	x	x	x	x
Pharetrospongia Strahani, *Sollas*	x	x	x	x	x
Plinthosella compacta, *Hinde*	x	x	x	x	x
„ squamosa, *Zitt.*	–	x	x	x	x
Plocoscyphia convoluta, *T. Smith*	x	x	x	x	x
„ labrosa, *T. Smith*	x	x	x	–	–
Porochonia simplex, *T. Smith*	–	–	x	x	x
Porosphæra globularis, *Phil.*	x	x	x	x	x
„ pileolus, *Lam.* (=P. urceolata, *Phil.*)	x	x	x	x	x
„ Woodwardi, *Carter*	–	x	x	x	x
Siphonia Kœnigi, *Mant.*	–	x	x	x	x
Steletta inclusa, *Hinde*	–	–	x	–	–
Stichophyma tumidum, *Hinde*	–	x	x	x	x
Ventriculites convolutus, *Hinde*	–	–	x	x	x
„ cribrosus, *Phil.*	x	x	x	x	x
„ decurrens, *T. Smith*	x	x	x	x	x
„ impressus, *T. Smith*	x	x	x	x	x
„ infundibuliformis, *S. Woodw.*	x	x	x	x	x
„ mammillaris, *T. Smith*	x	x	–	x	x
„ radiatus, *T. Smith*	x	x	x	x	x

CHAPTER IV.

THE UPPER CHALK IN SUSSEX.

2. THE INLAND PARTS.

GENERAL DESCRIPTION.

No one has yet attempted any detailed description of the Upper Chalk in the inland parts of Sussex; it would need a special reconnaissance and much careful collecting of fossils to trace the successive zones from east to west through the length of the county. A study of the slight lithological differences in the chalk and in the physical features of the country would doubtless assist anyone who undertakes such a reconnaissance. Thus my colleague, Mr. C. Reid, makes the following observations:—

"The chain of hills in the middle of the South Downs probably represents the feature made by the firmer chalk of the *Belemnitella* zones resting on the soft chalk of the *Marsupites* zone. Sections are extremely rare in this feature, and it cannot be followed for any great distance continuously, though isolated hills are traceable eastward along the same line as far as Brighton."

Mr. W. Hill examined some of the quarries near Lewes, Arundel and Houghton in 1897, and Mr. Rhodes collected fossils from these and other places.

Zonal exploration, so far as it has been carried, seems to show that the highest chalk in Sussex belongs to the zone of *Actinocamax quadratus*, and, further, that a greater thickness of this zone comes in at some localities than at others. Thus near Seaford there is at least 150 feet of this zone, while near Arundel there can hardly be more than 100 feet. As, however, the higher zone of *Belemnitella mucronata* is present in Hampshire, the full thickness of the *A. quadratus* zone probably comes in to the westward.

If the above view is correct, the Chalk must have been bent into broad undulations before the deposition of the Eocene series, and the flexures must be truncated unconformably by the basal plane of the Eocene, a conclusion which is of some importance.

STRATIGRAPHICAL DETAILS.

As the courses of the rivers Ouse, Adur, and Arun traverse the Chalk area from north to south at right angles to the strike of the beds, the valleys of these rivers form a convenient means of making three traverses across the Upper Chalk. Professor Barrois took advantage of this means of examining some of the inland exposures, and we propose to follow his example, taking the districts in the order above mentioned.

1.—Valley of the Ouse, near Lewes.

Some of the quarries which expose the zone of *Holaster planus* have been described when dealing with the Middle Chalk (see Vol. II. p. 402); but the section to be seen in the northern part of the large quarry known as Southerham limekiln quarry remains to be described. This locality has acquired a special interest from the curious bed of phosphatic chalk which is found in it. The following account is taken from Mr. Strahan's description.*

"A small bank at the eastern end of the long line of limekilns affords a good view of the junction of the Upper and Middle subdivisions, and of the phosphatic band in question. A section about the middle of the cutting showed in descending order:—

	Feet.
Massive chalk with flints.	
Flaky white chalk with a few flints (*H. planus*) - - -	4
Phosphatic chalk [with brown grains] and some nodules partly green and partly brown, up to 1½ inches in diameter	1½
Hard creamy limestone, nodular, with calcite in veins and cavities, some green coated nodules - - - - -	1½
Hard white compact chalk, traversed by branching pipes and thin laminæ of phosphatic chalk - - - -	3
Chalk as above but with less phosphatic matter - - -	3

West of this point the phosphatic band thickened up to 2 feet 4 inches in ten yards, while in the same distance to the eastward it decreased to about 2 inches only, showing the local and impersistent character of the deposit. It is curious that this phosphatic chalk does not occur in any of the other exposures near Lewes, though several traverse the horizon at which it occurs.

The underlying hard lime-stone resembles the Chalk Rock of more western counties and seems to be a local development of it.

Above these beds there is a considerable thickness of chalk, with regular layers of flints, from which Mr. Rhodes obtained Micrasters of the *cortestudinarium* type, *Cidaris clavigera*, *Rhynchonella reedensis*, and other fossils (see list on p. 49); but the highest part probably belongs to the zone of *M. coranguinum.*

The large quarries south of Offham exhibit a fine section through the zones of *Micraster cortestudinarium* and *Holaster planus* into the *Terebratulina* zone, but there is nothing which can be called "Chalk Rock," and the beds in which *Holaster planus* is common are not so thick as usual. The section was measured by Mr. Hill, who furnishes the following account of it :—

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* Quart. Journ. Geol. Soc., Vol. lii., p. 463. (1896).

		Ft.	in.
Zone of *M. cortestudinarium*, 89 *feet.*	Firm white chalk with frequent layers of flints, inaccessible - - - - - - about	50	0
	Firm white chalk, lying between two continuous layers of flint	2	8
	Firm white chalk with a few scattered flints, a *Micraster* like *cortestudinarium*	12	0
	Bed of flints	1	0
	Rough lumpy chalk, consisting of yellowish lumps in a soft mealy matrix	1	3
	Firm smooth white chalk with a few scattered flints, *Micraster præcursor*	10	0
	Firm white chalk with scattered flints	3	0
	Massive white chalk without flints	3	3
	Firm white chalk with scattered flints and a marked layer of flints at the base	6	0
Zone of *Holaster planus*, 58½ *feet.*	Firm white chalk with occasional flints in lines at about 3 feet intervals, *Micraster præcursor*	21	0
	A thin seam of marl	0	1
	Rough lumpy chalk, of yellowish lumps in a matrix which weathers to mealy dust *Cyphosoma radiatum*, *Terebratula carnea*, *Scaphites* like *æqualis*	1	3
	Massive course of creamy white chalk, rather lumpy, with *Hol. planus* and *Micraster sp.*	3	0
	Well marked seam of marl	0	2
	Rough lumpy whitish chalk with three layers of flints, *Hol. planus*	8	6
	Chalk full of scattered flints	1	6
	Rather rough lumpy chalk with greyish streaks, three layers of flints, *Hol. planus*, *Micr. Leskei*, and *Lima granosa*	11	0
	Seam of marl	0	3
	Firm, smooth white chalk, seen at intervals round the base of the quarry, *Ter. gracilis* var *lata*	6	0
	Total, about	142	0

Mr. Rhodes got many fossil from these beds, and the species identified by Mr. E. T. Newton seem to show that the fauna of the *H. planus* zone extends into and perhaps to the top of the beds grouped in 21 feet.

The highest part of the zone of *M. cortestudinarium* appears to be exposed in the upper pit on Offham Hill, now disused. At the bottom of this Mr. Rhodes found a band of hard yellow chalk, 1½ feet thick, and a continuous layer of flint about 8 feet above it. This pit is about 60 feet deep in chalk, with many layers of flints, and from it Mr. Rhodes obtained some of the fossils in the following list.

Part of the succession from the *Terebratulina* zone upward is exposed in the Bridgewick pit, north-east of Lewes; but it is not so accessible as at Offham. Many of the flints occurring in the zone of *M. cortestudinarium* are cavernous.

Still further west in a road-cutting on the escarpment west of Plumpton Mr. Hill found a set of hard beds, which appeared to represent the Chalk Rock, and above these a series which certainly includes parts of the zones of *H. planus* and *Micr. cortestudinarium*. From 10 feet above the hard beds he obtained a large *Micraster* since identified as *M. Leskei*, and two feet higher he found *M. præcursor*. Still higher, at from 20 to 25 feet above the hard beds, he obtained two *M. præcursor* of a facies suggesting the zone of *M. cortestudinarium*.

The zone of *Micraster coranguinum* comes in at the western end of the Southerham limekiln quarry. When collecting fossils here for the survey, Mr. Rhodes noticed a bed of hard yellow chalk at the highest point he could reach, about forty feet above the floor of the quarry; this bed he took to be at the junction of the *M. coranguinum* and *M. cortestudinarium* zones. Above it there is a considerable thickness of chalk, probably 100 feet, and Mr. Rhodes found that some blocks which had fallen from this were crammed with large fragments of *Inoceramus*.

A quarter of a mile further north, in what is called the "Snowdrop" or "Navigation" quarry, a similar section is seen. This is in the centre of the syncline (see Fig. 33, p. 55), and the beds are nearly horizontal. Mr. Rhodes reports the succession to be as follows:—

	Feet.
Chalk with many flints in layers from one to 3 feet apart, upper 30 feet inaccessible - - about	90
Marked layer of tabular flint.	
Hard yellowish chalk with occasional green-coated nodules - - - - - - - - about	4
Massive white chalk with layers of flints at intervals of 5 or 6 feet, many of the flints are cavernous. about	60

From the hard band Mr. Rhodes obtained *Echinocorys scutatus*, *Galerites albogalerus*, several *Micraster cortestudinarium*, *Micraster præcursor*, and some other fossils. The Micrasters have the aspect of those which occur at the junction of the two zones, but no typical *M. coranguinum* was found; the presence of *Galerites albogalerus* is suggestive of the higher zone, but does sometimes occur in that of *M. cortestudinarium*, so that we incline to regard this bed as the local top of that zone.

Fossils from Pits near Lewes.

The following list of fossils from the pits near Lewes is the result of collections made by Mr. Rhodes for the Geological Survey, supplemented by those recorded by Professor Barrois:—

——	Zone of Hol. planus.	Zone of Micraster cortestudinarium.	Zone of Micraster coranguinum.
Pisces.			
Ptychodus Oweni, *Dixon*		B	
„ mammillaris, *Ag.*		S	
Fish remains	S	S	
Cephalopoda.			
Scaphites *cf.* æqualis, *Sow.*	S		
Lamellibranchiata.			
Inoceramus Cuvieri, *Sow.*	S	S	S
„ Lamarcki, *d'Orb.* (non *Park*)	S		
„ mytiloides ? *Sow.*		S	
„ striatus, *Sow.*	S		
„ undulatus, *Mant.*	S		
„ sp.			S
Lima granosa, *Sow.*	S		
„ Hoperi, *Sow.*	S	S	S
Ostrea normaniana, *d'Orb.*	S	S	
„ semiplana, *Mant.*	S	S	
„ vesicularis, *Lam.*	S		
Spondylus spinosus, *Sow.*	S	S	S
„ striatus ? *Sow.*	S	S	
Brachiopoda.			
Crania parisiensis, *Defr.*		B	
Rhynchonella plicatilis, *Sow.*	S	S	S
„ limbata, *Schloth.*			S
„ reedensis, *Eth.*	S	S	
Terebratula semiglobosa, *Sow.*	S	S	S
Terebratulina gracilis, *Schloth.* var. lata, *Eth.*	S		
„ striata, *Wahl.*	S		
Bryozoa.			
Alecto sp.		S	
Entalophora sp.		S	
Eschara sp.		S	
Idmonea subcylindrica *Roemer*		S	
Homœosolen ramulosus, *Lonsd.*		S	
Echinodermata.			
Bourgueticrinus sp.		S	
Cidaris clavigera, *König*		S	S
„ Merceyi, *Cott.*			B
„ sceptrifera, *Mant.*		S	
„ subvesiculosa, *d'Orb.*		B	
Echinocorys scutatus, *Leske*	S	S	S
Cyphosoma corollare, *Klein*	S		
„ radiatum, *Sorig.*	S	S	
Galerites albogalerus, *Leske*		S	
Holaster planus, *Mant.*	S	S	
Micraster coranguinum, *Leske*			B

	Zone of Hol. planus.	Zone of Micraster cortestudm.	Zone of Micraster coranguinum.
Micraster corbovis, *Forbes* - - - -	S		
„ cortestudinarium, *Goldf.* - -		S	
„ Leskei, *Desm.* (= breviporus) -	S		
„ præcursor ? *Rowe* - - - -	S	S	
Salenia granulosa, *Forbes* - - - - -		S	
Annelida.			
Serpula cincta *Goldf.* - - - - - -		B	
„ ilium, *Sow.* - - - - - -		S	
„ plexus, *Sow.* - - - - - -		S	
Actinozoa.			
Diblasus sp. - - - - - - - -		S	
Spongida.			
Camerospongia campanulata, *T. Smith* -	S		
Porosphæra globularis, *Phil.* - - - -		S	
Ventriculites decurrens, *T. Smith* - -	S		
„ impressus, *T. Smith* - -	S	S	
„ mammillaris, *T. Smith* - -	S		
„ radiatus, *Mant.* - - -	S		

2.—Valley of the Adur.

There are not many exposures along this valley, but Mr. Reid found a large quarry, south of Lock Barn, near Beeding, showing about 140 feet of chalk with flints, which appears to belong to the zones of *M. cortestudinarium* and *M. coranguinum.*

Further south chalk with many flints is exposed in a pit, close to road and rail, at Old Erringham Farm, which is probably in the zone of *M. coranguinum.*

At Old Shoreham there is a quarry from which Prof. Barrois obtained *Marsupites*-plates, together with *Echinocorys gibbus, Micraster coranguinum, Rhynchonella octoplicata,* and other fossils. Here, therefore, the zone of *Marsupites* appears to be exposed; but at Kingston, to the south-east, there is chalk with numerous layers of flints, which probably belongs to the zone of *Act. quadratus.*

On the western side of the Adur valley there are three quarries near Lancing, two of which are certainly in the zone of *Marsupites.* One of these is south of Burwell's Farm, near Lancing College; the chalk here is very soft, and contains but few flints. Mr. Rhodes, when collecting here, found a bed about 15 feet above the floor of the pit in which *Ostrea acutirostris* was very abundant. The other is a large quarry in similar chalk south-west of Mill Hill, and in this Mr. Rhodes found *Marsupites*-plates to be abundant just above a layer of flints about 50 feet from the floor.

The third quarry is near Hill Barn, North Lancing, and shows about 30 feet of chalk with layers of flints; this is probably in the lower part of the *Act. quadratus* zone, for a Belemnite of this type was found, and Bryozoa are abundant, but no specimen of *Offaster*, generally so common in that zone, was discovered.

The following is a list of the fossils found by Mr. J. Rhodes in the quarries above mentioned:—

	Coranguinum zone.		Marsupite zone.			Quad. zone.
	Lock Barn.	Erringham Farm.	Old Shoreham.	Burwell Farm.	Mill Hill.	North Lancing.
Actinocamax sp.	—	—	—	—	—	x
Lima læviuscula ? *Sow.*	—	—	—	—	x	—
Ostrea acutirostris, *Nilss.*	—	—	—	x	x	—
„ normaniana, *d'Orb.*	—	x	—	x	—	?
„ vesicularis, *Lam.*	—	—	x	—	x	—
Pecten (Chlamys) cretosus, *Defr.*	—	—	—	—	x	x
„ (Neithea) 5-costatus, *Sow.*	—	—	—	x	—	x
Plicatula sigillina, S.P. *Woodw.*	—	—	x	—	—	—
Spondylus latus ? *Sow.*	—	—	—	—	x	x
„ spinosus, *Sow.*	x	—	—	—	—	—
Crania egnabergensis, *Retz.*	—	—	—	—	—	x
Rhynchonella plicatilis, *Sow.*	x	—	x	x	—	x
„ limbata, *Schloth.*	x	—	—	—	—	—
Terebratula semiglobosa, *Sow.*	x	x	—	x	—	—
Terebratulina gracilis, *var.*	x	—	—	—	—	—
„ striata, *Wahl.*	x	—	—	—	—	x
Alecto sp.	x	—	—	—	—	x
Escharina inelegans, *Sow.*	x	—	—	—	—	—
„ intricata, *Lonsd*	x	—	—	—	—	—
„ sp.	—	x	—	—	x	x
Diastopora sp.	x	—	—	—	—	x
Semieschara arborea, *d'Orb.*	—	—	—	—	—	x
Terebella lewesiensis, *Davies*	—	—	—	—	—	x
Serpula ampullacea, *Sow.*	—	—	—	—	—	x
„ fluctuata, *Sow.*	—	—	—	—	—	—
„ granulata, *Sow.*	—	—	—	—	—	—
„ macropus, *Sow.*	—	—	—	—	—	—
„ plexus, *Sow.*	—	—	—	—	—	—
Bourgueticrinus ellipticus, *Goldf.*	—	x	—	—	—	x
Cidaris clavigera, *König.*	x	x	—	—	—	—
„ sceptrifera, *Mant.*	—	x	—	—	—	—
„ Merceyi, *Cott.*	—	x	—	—	—	—
Echinocorys scutatus, *Leske*	—	x	x	x	x	x
Micraster coranguinum, *Klein*	—	x	—	x	—	—
„ cortestudinarium, *Goldf.*	x	x	—	—	x	—
„ præcursor, *Rowe.*	x	x	—	—	—	—
Marsupites testudinarius, *Schloth.*	—	—	x	x	x	—
Parasmilia sp.	x	—	—	—	—	x
Callodictyon ?	—	—	—	—	—	x
Pharetrospongia Strahani, *Sollas.*	x	—	—	—	—	—
Porosphæra globularis, *Phil.*	x	x	—	x	—	—
„ urceolata, *Phil.*	—	—	—	—	—	x
„ Woodwardi, *Carter*	—	—	—	x	—	—
Ventriculites cribrosus, *Phil.*	x	—	—	x	—	—

3.—Valley of the Arun and Westward.

No good sections of the zone of *H. planus* were found near Amberley, but it is traversed by the railway cutting about half a mile south of the station, at the east end of a short tunnel. Mr. Hill examined this in 1897 and described the chalk as lumpy and of a creamy-yellow tint; no continuous section can be taken, but Micrasters are very numerous, and are all of the "low-zonal" *M. præcursor* type; they are associated with *Echinocorys scutatus*, *Rhynchonella plicatilis*, *Rh. reedensis*, *Terebratula carnea*, etc. These beds probably belong to the upper part of the *Holaster planus* zone.

Parts of the two lower zones are exposed also in the quarry on Duncton Hill, about two-thirds of a mile south-west of Duncton church. Mr. Reid found the lower part obscured by talus, but the face above this exposed about 2 feet of hard nodular chalk, surmounted by 20 feet of chalk, with many flints, which are grey inside. This probably includes the junction of the zones of *H. planus* and *M. cortestudinarium*.

We are indebted to Mr. R. M. Brydone, F.G.S., for the following list of fossils which he has found in this quarry:—

Ostrea vesicularis.
Exogyra haliotoidea.
Inoceramus sp.
Plicatula Barroisi.
Terebratula semiglobosa.
Rhynchonella plicatilis.
" reedensis.

Cidaris clavigera.
Cyphosoma sp.
Echinocorys gibbus.
Holaster planus.
Micraster sp.
Pentacrinus.

The lower part of the zone of *M. coranguinum* and its junction with that of *M. cortestudinarium* are exposed in the large quarry south-west of Houghton. The section here was taken by Mr. Hill in 1897, and is as follows:—

		Ft.	*in.*
Zone of *M. coranguinum.*	Chalk with layers of flints (inaccessible) - -	? 50	0
	Seam of flint, nearly continuous, but breaking here and there into nodules - - - -	0	2
	Rather hard white chalk with scattered flints, yielded a typical *Micraster coranguinum* and *Echinocorys scutatus* - - - - - -	10	0
	Continuous seam of flint - - - - - -	0	3
	Rather soft white chalk with a few scattered flints near the base - - - - - - - -	5	0
	Soft mealy chalk, with lumps of hard yellowish compact chalk, with *Micraster præcursor* and other fossils - - - - - - - -	1	6
	Thin seam of marl - - - - - - -	0	1
	A massive bed of firm white chalk, with a few scattered flints near the base - - - -	3	0

		Ft.	in.
Zone of *M. cortestudinarium.*	Massive bed of rough lumpy chalk, hard creamy yellow lumps cemented together in a matrix of lighter colour, the whole course being hard	3	3
	Continuous seam of flint - - - - - -	0	2
	Hard white chalk veined with grey - - -	2	6
	A conspicuous layer of large flints - - -	0	8
	Smooth and firm white chalk, rather broken up where measurements were taken, forming a sort of ledge in this part of the quarry - -	4	6
	Massive firm white chalk without flints - -	3	6
	Massive firm white chalk, with flints both scattered and in layers ; no fossils seen about	50	0
	About - - - - - - - -	134	0

Owing to the scarcity of fossils the exact limit-plane between the zones cannot be determined, and it is possible that it should be taken rather higher up than we have placed it. Micrasters taken from the 18 inches of soft mealy chalk are all of the *præcursor* group and are such as would occur about the horizon of passage from one zone to the other, and the other fossils (see p. 55) do not include any special zonal guide.

Other pits to the southward show white chalk with layers of black flints, featureless, but unquestionably belonging to the zone of *M. coranguinum.* From one half a mile west of South Stoke Mr. Rhodes obtained *Septifer lineatus, Micraster coranguinum,* and *Ventriculites cribrosus.*

A large quarry at the back of the Black Rabbit Inn appears to show the junction of the *M. coranguinum* and *Marsupites* zones. Mr. Hill reports that the lower 60 or 70 feet here exposed consists of firm chalk with many layers of black flints ; the upper 50 feet shows soft chalk with few flints ; only a few sparsely scattered nodules or in lines at distant intervals.

Similar chalk with few flints is seen in the river-cliff at Burpham, on the eastern side of the valley. This was searched by Mr. Rhodes, who found *Marsupites* and *Terebratulina Rowei* in a band, which is first seen about 50 feet above the river, but comes down to the water-level further south, and thus definitely fixes the position of the *Marsupites* zone at this place. About 15 feet above this band he found a bed of oysters like that at Burwells Farm, Lancing. Near the top of the cliff he noticed a layer of lumpy yellow-stained chalk, containing some *Serpulæ, Bryozoa,* and decomposed Sponges.

The section is continued in a pit by the high road W.N.W. of Warning Camp Hill, of which Mr. Rhodes sends me the following note :—" About 10 feet above the floor of the pit is a bed of stained chalk, containing rotted sponges, *Serpula,* and a layer of flint nodules, which seems to be the same as that seen at the top of Burpham cliff. Above this is chalk with few flints, and about 22 feet above the floor is a 4-inch layer of marl, succeeded by chalk with marly layers, for 12 feet, in which *Offaster pillula* is

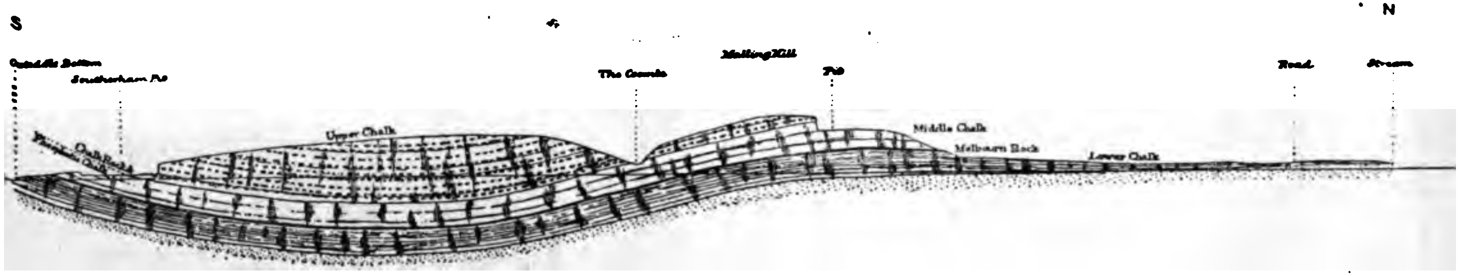

FIG. 33.—Section through the hills east of Lewes. Scale 6 inches to a mile.

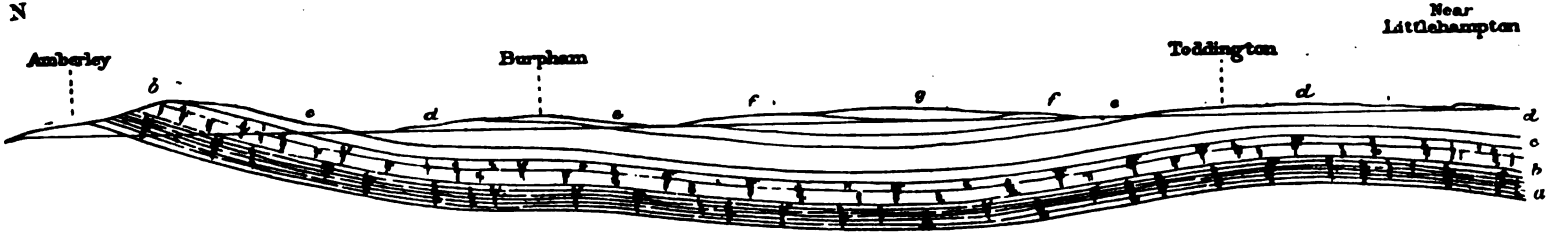

FIG. 34.—Section along the east side of the Valley of the Arun.
Horizontal Scale, one inch to a mile. Vertical Scale, 800 feet to an inch.

g. Eocene Beds.
f. Zone of *Act. quadratus.*
e. Zone of *Marsupites.*
d. Zones of *Micrasters.*
c. Zone of *Hol. planus.*
b. Middle Chalk.
a. Lower Chalk.

common. This may be regarded as the base of the *Actinocamax quadratus* zone. The large pit on Warning Camp Hill shows chalk with some thin flint floors and frequent layers of flint nodules, and is probably in the *Act. quadratus* zone, though its base may be in the lower zone, as Mr. Rhodes found a *Marsupites*-plate here. By the side of a small stream west of Arundel is a pit in chalk with layers of black flints, probably in the zone of *Act. quadratus*, though no *Belemnite* was found.

The following is a list of fossils obtained by Mr. Rhodes from the quarries above mentioned :—

	Houghton.					
	Lower Beds.	Higher Beds.	Burpham.	Warning Camp.	Warning Camp Hill.	Arundel.
Pisces.						
Ctenothrissa	—	—	x	—	—	—
Fish vertebræ	—	—	—	—	x	—
Mollusca.						
Inoceramus sp.	—	x	x	x	x	—
Lima Hoperi, *Sow.*	x	x	x	—	—	—
„ semisulcata, *Sow*	x	—	—	—	—	—
Ostrea acutirostris, *Nilss.*	—	—	x	—	—	—
„ normaniana, *d'Orb.*	x	—	x	—	—	—
„ semiplana, *Mant.*	—	—	—	—	x	—
„ vesicularis, *Lam.*	x	x	x	—	—	x
Pecten (Chlamys) cretosus, *Defr.* (= P. nitidus, *Mant.*)	—	—	—	x	x	—
„ (Neithea) quadricostatus, *Sow*	—	—	x	—	—	—
„ „ quinquecostatus, *Sow.*	—	—	x	—	x	x
Spondylus dutempleanus, *d'Orb.*	—	—	x	—	—	—
„ spinosus, *Sow.*	—	x	x	—	—	—
„ striatus ? *Sow.*	—	—	?	x	x	x
Brachiopoda.						
Crania sp.	—	—	x	—	—	—
Kingena lima, *Defr.*	—	—	x	—	—	—
Rhynchonella limbata, *Schloth.*	—	x	x	—	x	x
„ plicatilis, *Sow.*	x	x	—	—	—	—
„ „ (young)	—	—	x	—	—	—
Terebratula biplicata ? *Sow.*	—	x	—	—	—	—
„ semiglobosa, *Sow.*	x	x	—	—	x	—
Terebratulina Rowei, *Kitchin*	—	—	x	—	—	—
„ striata, *Wahl.*	—	—	x	—	—	—
Bryozoa.						
Alecto sp.	—	x	x	—	—	—
Berenicea papillosa, *Reuss.*	—	x	—	—	—	—
„ sp.	—	—	x	—	—	—
Entalophora obliqua ? *d'Orb.*	—	—	—	—	—	x
„ sp.	—	—	x	—	x	—
Eschara sp.	—	—	x	—	—	x

	Houghton.					
	Lower Beds.	Hgher Beds.	Burpham.	Warning Camp.	Warning Camp Hill.	Arundel.
Escharina sp - - - - - -	–	–	x		x	x
Idmonea sp. - - - - - -	–	–		–	x	-
Pustulipora (Hammia) pustulosa, *Goldf.* - - - - - -	–	–	x	–	x	–
Semieschara sp.- - - - -	–	–	–	–	x	x
Annelida.						
Serpula ampullacea, *Sow*- - -	–	–	–	–	–	x
„ plexus, *Sow.* - - -	–	x	x	x	–	–
„ pusilla, *Sow.* - - -	–	–	–	–	–	x
„ turbinella, *Sow.* - - -	–	–	–	–	x	x
Terebella lewesiensis, *Davies* - -	–	–	–	–	–	x
Echinodermata.						
Bourgueticrinus ellipticus, *Goldf.*	–	–	x	–	–	x
Cidaris (spines) - - - -	–	–	–	–	x	x
Echinocorys scutatus, *Leske* - -	–	x	x	x	x	–
Galerites sp. - - - - - -	–	–	x	–	–	–
Goniaster (ossicles) - - - -	x	–	x	–	x	–
Holaster planus, *Mant* - - -	x	–	–	–	–	–
Marsupites testudinarius, *Schloth.* -	–	–	x	–	x	–
Micraster coranguinum, *Klein* -	–	x	?	–	–	–
„ cortestudinarium, *Goldf*	x	–	–	–	–	–
„ præcursor, *Rowe* - -	x	x	–	–	–	–
Offaster pillula, *Lam.* - - -	–	–	x	x	–	–
Parasmilia sp. - - - - -	–	–	x	–	-	–
Spongida.						
Callodictyon sp. - - - -	–	–	x	x	–	–
Porosphæra globularis, *Phil.*- -	–	–	x	x	–	x
„ urceolata, *Phil.*- -	–	–	–	–	x	–
„ Woodwardi, *Carter* -	–	–	x	x	x	–
Placotrema cretaceum, *Hinde* -	–	x	–	–	–	–
Ventriculites cribrosus, *Phil.* -	–	x	–	x	–	–
„ impressus, *T. Smith* -	–	x	x	–	–	–
„ sp. - - - - -	–	–	–	–	x	x

A boring recently made at Goodwood has traversed the Chalk for a depth of 1,012 feet without quite reaching its base. Details are given by Mr. C. Reid in a memoir on " The Geology of the Country near Chichester," 1903, p. 31.

CHAPTER V.

THE UPPER CHALK IN SOUTH AND CENTRAL HAMPSHIRE.

GENERAL DESCRIPTION.

Under this head we shall describe what is known with regard to the zones of the Upper Chalk in that part of Hampshire which lies south of a line drawn midway between the limits of the Tertiary basins of London and Hampshire, and we may consider such a line to pass through the towns of Andover and Micheldever.

This area includes the prolongation of the southern axis of the great Wealden uplift, the anticline which runs through Petersfield and Winchester. It also includes an axis which crosses the valley of the Test near Stockbridge, which was first discovered by Professor Barrois in 1876; this anticline may be a prolongation of the first, but we are inclined to regard it as a separate subsidiary axis, setting in rather to the north of the point where the Winchester axis appears to die out.

From these two anticlines the beds dip gently to the north, and soon become flattened out over the central part of the broad area of the Chalk; southwards the dip is a little steeper, and is steadily maintained till the higher zones are carried beneath the main boundary of the Eocene series.

Further south, and within the Eocene area, there is another important anticlinal uplift, that of the Portsdown and Chichester anticline, which brings the highest zones of the Chalk up to the surface along an area about two miles in breadth to the north of Portsmouth and Chichester harbours.

The chalk of the southern part of Hampshire is, of course, a continuation of that of Sussex, and, so far as we know, the several zones present the same general characters in Hants as they do in Sussex. Apart from the special abundance or restriction of certain species of fossils by which the zones may be recognised, they are also distinguishable to a certain extent by the characters and relative abundance of the flints which they contain. Thus, those in the two lowest zones are generally solid and dark grey inside, this grey flint often blending gradually into a white crust. The zone of *Micraster coranguinum* contains a larger quantity of flints per cubic yard than any other part of the Chalk; the layers are nearer together and the flints are often large, and frequently of a reddish or brownish colour, but often cavernous, and enclosing remains of Sponges and of *Bryozoa.*

The zone of *Marsupites* presents a great contrast in having but few flints, either scattered or arranged along planes at distant vertical intervals, and occurring but sparsely even along such a plane. In the zone of *Actinocamax quadratus* flints become more abundant again, but there is generally from 3 to 6 feet, and sometimes as much as 10 or 12 feet of chalk between the layers of flints; moreover, the flints are generally small, or rather small, solid and black inside, with a moderately thick white crust or rind, which is often stained yellow on the outside. In the zone of *Belemnitella mucronata* flints occur in layers at still more frequent intervals, but they are generally small, rounded, and have only a thin white crust.

No precise estimates have yet been made of the thickness of the several zones, but Mr. Ch. Griffith, of Winchester College, to whom I am indebted for much information respecting the Chalk of Hampshire, agrees with me in thinking that the following estimates are approximately correct:—

Zone of Bel. mucronata - - -	about 80 feet.	
„ Act. quadratus - - -	200 „	or more.
„ Marsupites - - -	150 „	
„ Micr. coranguinum - -	200 „	or more.
„ „ cortest. and H. planus	50 to 60 feet.	
	from 680 to 700 feet.	

Owing to the irregular outcrop of the beds, it will be convenient to describe the exposures in separate areas from east to west.

1. Outcrops near Alton and Petersfield, with Inlier of Portsdown.

The zone of Holaster planus is believed to pass from Sussex into Hampshire on Butser Hill, south of Ramsdean and Petersfield. Thence a line for the representative of the Chalk Rock has been drawn westward along the summit of the downs that form the southern border of the Meon valley to Combe, and thence for some distance down the valley which opens westward from that place. Returning, it passes by Drayton, north-west of East Meon, and thence eastward to Bordean and Froxfield, whence it runs north-westward again in an irregular manner.

But my colleague, Mr. Hawkins, informs me that there are no good sections in this district, and that he found no exposures of Chalk Rock or hard nodular chalk, so that the line engraved on the new one-inch map of the Geological Survey is merely an approximate boundary drawn below all exposures of the "chalk with many flints."

More recently Mr. C. Griffith has found the chalk with *Hol. planus* exposed in a chalk-pit, near Becksteddle Farm, south of East Tisted, and again in a cutting on the new railway line nearly 3 miles N.W. of Alton.

Higher Zones.—Along the continuation of the South Downs into Hampshire there are occasional exposures of chalk with many flints, which probably belong to the zone of *Micraster coranguinum*.

The only zonal identification of any exposure in this district, however, is that of a small quarry near Clanfield, about 5 miles south-west of Petersfield, where Messrs. Griffith and Brydone have found *Marsupites*-plates and about thirty other species of fossils, a list of which they have kindly placed at my disposal (see p. 65). The chalk is soft white, and contains many solid black flints scattered through it, but not in layers.

The zone of *Actinocamax quadratus* comes on further to the south, and was identified by Professor Barrois, who remarks: "Many quarries are open at Seberton, the chalk dipping at 5° to the south, and containing many black flints, rather large and of rounded shapes. At Inklefield Farm a quarry shows chalk in contact with the Eocene, with very many flints in regular layers about 5 feet apart; they are rounded and black throughout. *Echinocorys ovatus* is abundant, and I also found *Spondylus latus*."

It is very probable that this chalk at Inklefield belongs to the zone of *Belemnitella mucronata*, for though that has not yet been recognised as existing along this part of the Eocene border, still it is found in the Portsdown inlier to the southward.

The Portsdown inlier extends from the south of Havant to tthe north of Fareham, and is a tract of chalk brought up within the Eocene area by an anticlinal axis. The zone of *Belemnitella mucronata* was recognised here by Professor Barrois, and the following is a translation of his account of the district:—"There is first a series of quarries at the base [of the hills] by Bedhampton, Farlington, Cosham, and Paul's Grove, in which flints are either few or entirely absent. Where there are few flints, as at Paul's Grove, the chalk is identical with that of Margate, both in its mineralogical characters and in its fauna. These quarries show a thickness of about 160 feet of chalk belonging to the zone of *Marsupites*. In that at Farlington, as well as at the bottom of the large quarry at Paul's Grove, there is a yellow nodular band, which is possibly the same as that seen at Rottingdean (near Brighton) . . . . At the top of the hills the chalk contains many flints; it can be examined near Bedhampton, Belmont Castle, and especially in the ditches of the forts which have been constructed on these heights—Fort Nelson and Farlington Fort; at the latter the beds dip northward. At 12° flints are numerous, rounded, black with a thin white rind, and some are hollow . . . . About 60 feet of such chalk is visible, and it belongs to the zone *à Belemnitelles* (*niveau de Meudon*). The *Cardiaster Héberti* and *Belemnitella mucronata* which I found are quite characteristic." ("Recherches," p. 34).

It is only necessary to remark that the lower zone referred to is that of *Actinocamax quadratus* and not that of *Marsupites*, and that the remark that it is identical with the Margate Chalk is not quite correct.

2. WINCHESTER DISTRICT.

The zone of Holaster planus is exposed at several places near Winchester. The junction of the zones of *Terebratulina* and *Holaster planus* was formerly well exposed in a large old quarry on the western side of Twyford Down, but Mr. Griffith informs me that a large part of this is now obscured by *talus*, and only small exposures exist at the top and bottom of the pit.

Fortunately, however, Prof. Barrois found the section fairly clear when he was in England, and has recorded it on p. 41 of his "Recherches." He says the dip observable here was 8° to the south, and the following is a translation of his account, read in descending order :—

		Ft.	*in.*
	9. Chalk with layers of flints, which are generally cavernous. *Inocerami* with thick shells - -	13	0
H. planus zone.	8. Nodular chalk with numerous flints, partly covered by talus, *Micraster cortestudinarium* - - -	33	0
	7. Nodular white chalk, with *Holaster planus*, *Micraster breviporus*, *Rhynch. Cuvieri*, *Spondylus spinosus*, etc. - - - - - - - - -	6	6
Terebratulina zone.	6. Layer of grey clay - - - - - - - - -	0	1½
	5. Very nodular chalk - - - - - - -	13	0
	4. Layer of yellow nodules in white chalk - - -	0	8
	3. Compact white chalk, *Terebratulina gracilis* [? *var. lata*] - - - - - - - - -	0	8
	2. Band of soft marl - - - - - - - -	0	6
	1. Compact white chalk, with bands of marl, a few scattered black flints - - - - - - -	13	0
	About	80	0

Prof. Barrois does not indicate any zonal limits, and the brackets are consequently my own, the base of the *H. planus* zone being placed where that species and Micrasters first become common fossils. No. 9 may belong to the overlying zone, to which Prof. Barrois refers the beds seen in an adjoining quarry by the side of the road a little further south. He describes the chalk in this pit as hard and nodular, containing brownish-black flints of irregular shapes, and the following fossils: *Micraster cortestudinarium*, *M. breviporus ?*, *Holaster placenta.* Of this quarry Mr. Griffith writes :—"The chalk is gritty and rather soft when wet, much harder when dry, so that fossils are otfen difficult to clean. The pit has been continuously worked and well searched for fossils, and has consequently yielded a long list of species with some of the rarest forms. Casts of Cephalopoda and Gasteropoda are fairly common at times." He considers the chalk to be part of the zone of *Holaster planus*.

This zone is also exposed in a quarry by the railway crossing at St. Cross, which has yielded a few of the usual fossils.

Mr. Griffith considers it doubtful whether any definite zone of *Micraster cortestudinarium* can be distinguished in the Winchester district, but specimens apparently referable to this species were found in the tunnel under St. Giles's Hill, and in the cutting at the northern entrance to the tunnel, which he believes to be in the base of the *M. coranguinum* zone.

The zone of M. coranguinum is shown in pits near Alresford, Ovington, Itchen Abbas, Chilland, Martyr-Wortley, and Easton, Professor Barrois remarks that in all these quarries the dip is to the north, that flints are numerous, brownish and banded (zonés), occurring in layers at distances of 3 to 6 feet apart, and that specimens of *Micraster coranguinum* are abundant and well preserved.*

To Mr. C. Griffith, of Winchester College, and to Mr. R. M. Brydone, F.G.S., I am indebted for the following particulars:—The chalk of the railway cutting near Headbourne Worthy probably belongs to the *M. coranguinum* zone. The record of *Marsupites* there is based on a single plate found many years ago by the Rev. A. B. Burnett, but neither Mr. Griffith nor Mr. Brydone have ever found one, and the latter writes: "The relative abundance of *Galerites* and *Cidaris* would lead me to refer it to the *M. coranguinum* zone." The base of the zone is exposed in a cutting beyond the northern end of St. Giles' Hill tunnel, where the dip is about 6½° north. Higher beds are seen in the next cutting to the north and in quarries north-east of Winnal, from which many fossils have been obtained by the members of the Natural History Society of Winchester College.

A little further to the north-east are two other quarries, one south and the other west of the village of Easton. Of that to the south Mr. Griffith writes:—"The chalk is soft; flints are numerous, both scattered and in layers; they are of various sizes and shapes, the interior black, the outer skin fairly thick to thin, white, but sometimes showing a pinkish tinge. At the south end of the pit is a large sand-pipe filled with clayey gravel. Fossils are less numerous than at Winnal."

There seem to be no exposures of the *M. coranguinum* zone on the southern side of the Winchester anticline. Professor Barrois referred the chalk seen to the south of Compton to this zone, but as the Winchester collectors have found that *Offaster pillula* is the most abundant fossil in the pit and road-cutting, which are the only exposures there, this chalk cannot be older than the *Marsupites* zone, and most probably belongs to the zone of *Act. quadratus.*

The Marsupites zone.—According to Professor Barrois, the chalk of this zone completely surrounds the Winchester uplift, and he may be correct. It is certainly present on the western and eastern sides, and probably on the southern, but it is doubtful whether it comes in on the northern side between Winchester and Micheldever. To the south of Winchester it should come in somewhere near Compton, but there seems little space for it and the *M. coranguinum* zone as well, nor have any *Marsupites*-plates yet been found at any of the exposures near that village. Possibly there is a line of fault across the valley there.

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* Recherches sur le Terr. Crét. Sup., 1876, p. 39.

East of Winchester, and near Alresford, there are several exposures in this zone. It is seen in the railway cutting at Alresford, in that at Ropley, and in two pits on the road from that place to Petersfield, nearly three miles south-east of Ropley Church. Mr. Griffith writes that the chalk in these sections is soft, and contains many scattered flints, which are solid and black inside, but have thick white rinds or crusts, the outside surface being often of a yellow colour. Plates of *Marsupites* are common, together with the pyramidal variety of *Echinocorys scutatus*, and the short thick barrel-shaped variety of *Bourgueticrinus*, both of which are especially characteristic of this zone in Hampshire.

The zone of Actinocamax quadratus forms a broad band along the northern border of the Eocene area south and south-west of Winchester, and is exposed in pits at Shawford, near Twyford, Hensting Farm, and Marwell road, and in three pits at Hursley. My informant, Mr. Griffith, describes the chalk seen in these pits as soft and white, massive where unweathered, with many flints, both scattered and in layers, at distances of 3 or 4 feet apart.

North-east of Winchester Mr. Griffith has found it at Lyeway, near Ropley, but nowhere else in a northern direction within the limits of the area we are now dealing with. It has a wide extension in the more northern part of Hampshire.

The zone of Belemnitella mucronata may also emerge in places along the border of the Eocene tract, though the evidence for it so doing is not at present very strong. Mr. Griffith communicates the following facts regarding its occurrence. A specimen of *Bel. mucronata* was found recently (February, 1898) in a pit on the western side of the railway at Shawford. Again, at Bishops Waltham in a pit by the gas works there is chalk, with many very thin-skinned flints, which has yielded *Magas pumilus*, a fossil which rarely occurs below the zone of *Bel. mucronata* in Hampshire.

There can, of course, be no doubt that the zone of *Bel. mucronata* exists beneath the Eocene area, since it is present at Portsdown and also near Salisbury, as will be presently shown; it is consequently merely a question whether its outcrop is continuous round the border of the Eocene Beds or whether these latter overlap in places so as to rest on the lower zone of *Act. quadratus*.

3. STOCKBRIDGE AND THE VALLEY OF TEST.

Professor Barrois was the first to point out that the two main anticlinal axes of the Wealden uplift were prolonged through the Chalk plateau of Hampshire. In descending the valley of the Test he discovered that the base of the Upper Chalk was brought up by an anticlinal flexure near Stockbridge, and he inferred that this was a continuation of the Winchester axis.* Not having been able to visit this country ourselves, we cannot do more than give a translation of Professor Barrois' account. He says: "To the south of Whitchurch and Andover the general inclination of the beds becomes northerly, so that the zone of *M. coranguinum* soon makes its appearance in this direction. The heights [above the valley] consist of the *Marsupites* chalk, but at the level of the river Test at Middleton, near the farm of South Side, is a quarry which I refer to the zone of *M. coranguinum*. The section is as follows:—

	Ft.	*in.*
4. White chalk without flints, resting on the indurated surface of that below - - - - - - -	3	0
3. Chalk with numerous layers of flints, which are hollow and full of sponge spicules, *M. coranguinum*, *Echinoconus conicus*, and other fossils - - - - -	16	6
2. Thick continuous seam or floor of flint - - - - -	0	2
1. Chalk forming the floor of the quarry.		

"To the South of Middleton, by Drayton and Van Dyke, the flints are banded (zonés) and in regular layers. The river Anton traverses the same beds, and a quarry at Cottonworth shows the *M. coranguinum* chalk dipping north at 6°.

"At Kilecombe Bridge is a large quarry in soft white chalk with layers of flints from 2 to 3 feet apart, but poor in fossils; similar chalk continues as far as Leckford . . . . .

"Near the bridge over the railway at Longstock the chalk is soft and homogeneous, with many flints, small, black, and scattered; it is divided into beds about 18 inches thick either by flint layers or by seams of marl, and dips at 2° to the north; *Micraster coranguinum*, *Inoceramus involutus*, *Rhynchonella plicatilis* occur. Above Longstock there is chalk with many flints in layers about a foot apart . . . . separated into beds by layers of marl; fragments of large *Inocerami* abound in this quarry, forming continuous layers. This chalk may also belong to the *M. coranguinum* zone."

Nearer Stockbridge, however, he found chalk with *Micraster cortestudinarium*, and south of that place nodular chalk with

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*Recherches, 1876, p. 52. As already stated, however, it may be an independent axis.

Holaster planus and *Scaphites Geinitzi*, but both these species appear to be rare, and Messrs. Griffith and Brydone are inclined to consider this exposure to be in the zone of *M. cortestudinarium.* Nothing is visible which can be called "Chalk Rock." At Marsh Court Farm is a quarry which Professor Barrois describes as showing the junction of the zones of *M. cortestudinarium* and *M. coranguinum*, but this supposition appears to be based mainly on the occurrence of a marked plane of division below the marly seam. The section he gives is as follows:—

	Feet.
White chalk, with irregular layers of hollow black flints, *M. coranguinum*	20
Seam of light grey marl.	
Chalk with solid black flints, its upper surface worn and indurated	?

As Hoopers Bottom Farm is another pit, which he referred to the upper part of the *M. coranguinum* zone, and at Park House Farm he saw chalk with few flints dipping at about 8° to the south, and referable to the *Marsupites* zone, and from it he obtained *Marsupites testudinarius, Galerites albogalerus, Echinocorys gibbus,* and *Bourgueticrinus ellipticus.* This exposure Mr. Griffith has not been able to find.

"The last exposures," writes Professor Barrois, "are just below the Tertiaries near Mottisfont Station; in these fine quarries the dip is 3° to the south; the chalk is soft and white with few flints in the lower 50 feet, but in the upper 50 feet flints are more numerous in layers, light grey and slightly banded." From these pits he obtained *Inoceramus lingua, Pecten cretosus* and *Offaster pillula,* and there can be little doubt that the upper beds are what we now refer to the zone of *Actinocamax quadratus.*[*]

Fossils from the Upper Chalk in the South and Central Parts of Hampshire.

For the following list of fossils I am indebted almost entirely to the researches of Mr. Ch. Griffith, of Winchester, and Mr. R. M. Brydone, who have collected carefully from all the most accessible exposures in the central part of Hampshire. They have furnished me with lists of the species found at each locality, and it is from these lists that the one now printed has been drawn up. Most of the specimens are in the Museum of the Winchester College Natural History Society.

Most of the species listed under the head of Portsdown are quoted from Professor Barrois' work ("Recherches" pp. 34 and 52).

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[*] Mr. Griffith informs me that *A. granulatus* does occur in the upper part of the quarry. The lower part is obscured by talus.

	Zone of H. planus.	Corang. zone.		Marsup. zone.		Quadratus zone.		Mucronata zone.
		Winchester.	Stockbridge.	Clanfield.	Winchester.	Hursley, &c.	Portsdown.	Portsdown.
	1	2	3	4	5	6	7	8
Pisces.								
Cimolichthys lewesiensis, *Leidy*	–	–	–	–	–	6	–	–
Enchodus lewesiensis, *Mant.*	1	–	–	–	–	6	–	–
Lamna appendiculata, *Ag.*	1	–	–	4	–	6	–	–
Macropomà sp.	–	–	–	–	–	6	–	–
Oxyrhina Mantelli, *Ag.*	1	2	–	–	–	6	–	–
Protosphyræna ferox, *Leidy*	–	–	–	–	–	6	–	–
Ptychodus mammillaris, *Ag.*	1	–	–	–	–	–	–	–
,, polygyrus, *Ag.*	–	2	–	–	–	–	–	–
Scapanorhynchus rhaphiodon, *Ag.*	–	2	3	–	–	6	–	–
Cephalopoda.								
Ammonites [Lytoceras] Jukesi, *Sharpe*	–	–	–	–	–	6	–	–
,, [Prionoc] Neptuni, *Gein.*	1	–	–	–	–	–	–	–
,, [Pachydiscus] peramplus, *Mant.*	1	–	–	–	–	–	–	–
Aptychus leptophyllus, *Sharpe*	–	–	–	–	–	6	–	–
,, Portlocki, *Sharpe*	–	–	–	–	–	6	–	–
Actinocamax granulatus, *Blainv.*	–	–	–	4	–	–	–	–
,, quadratus, *Defr.*	–	–	–	–	–	–	7	–
,, **verus**, *Miller*	–	2	–	–	–	–	–	–
Belemnitella lanceolata, *Schloth.*	–	–	–	–	–	6	–	8
,, mucronata, *Schloth.*	–	–	–	–	–	–	–	–
Baculites bohemicus, *Fritsch*	1	–	–	–	–	–	–	–
,, Faujasi, *Sow.*	1	–	–	–	–	–	–	–
Crioceras ellipticum, *Mant.*	1	–	–	–	–	–	–	–
Heteroceras reussianum, *d'Orb.*	1	–	–	–	–	–	–	–
Ptychoceras Smithi, *Woods*	1	–	–	–	–	–	–	–
Scaphites Geinitzi, *d'Orb.*	1	–	–	–	–	–	–	–
Nautilus sublævigatus, *d'Orb.*	1	–	–	–	–	–	–	–
Rhynchoteuthis sp.	1	–	–	–	–	–	–	–
Gasteropoda.								
Aporrhais Mantelli, *Gard.*	1	–	–	–	–	–	–	–
Avellana cf. Humboldti, *Müller*	1	–	–	–	–	–	–	–
Cerithium sp.	1	–	–	–	–	–	–	–
Dentalium turoniense, *Woods*	1	–	–	–	–	–	–	–
Pleurotomaria perspectiva, *Mant.*	1	–	–	–	–	–	–	–
Trochus Schlüteri, *Woods*	1	–	–	–	–	–	–	–
Solariella gemmatus, *Sow.* (Turbo)	1	–	–	–	–	–	–	–
Lamellibranchiata.								
Caprotina sp.	–	–	–	–	–	6	–	–
Cypricardia trapezoidalis, *Roemer*	1	–	–	–	–	–	–	–
Exogyra haliotoidea, *Sow.*	–	2	–	–	5	–	–	–
Inoceramus Cuvieri, *Sow.*	–	–	–	–	–	–	–	–
,, involutus, *Sow.*	–	2	3	–	5	–	–	–

	Zone of H. Planus.	Corang. zone.		Marsup. zone.		Quadratus zone.		Mucronata zone.
		Winchester.	Stockbridge.	Canfield.	Winchester.	Hursley, &c.	Portsdown.	Portsdown.
	1	2	3	4	5	6	7	8
Inoceramus sp. (like latus)	1	–	–	–	–	–	–	–
,, sp.	1	2	3	4	5	6	7	–
Lima granosa, *Sow.*	1	–	–	–	–	–	–	–
,, Hoperi, *Sow.*	1	2	–	4	–	6	–	–
,, læviuscula, *Sow.*	–	–	–	–	–	6	–	–
,, pectinata, *d'Orb.*	1	–	–	4	–	6	–	–
Ostrea canaliculata, *Sow.*	1	2	–	4	–	6	–	–
,, ,, var. striata	–	–	–	–	–	6	–	–
,, curvirostris, *Nilss.*	–	–	–	4	–	6	–	–
,, hippopodium, *Nilss.*	–	2	3	4	5	6	–	–
,, normaniana, *d'Orb.*	–	2	–	–	–	–	–	–
,, vesicularis, *Lam.*	1	2	–	4	–	6	7	8
,, wegmanniana, *d'Orb.*	–	–	3	4	–	6	–	–
Pecten jugosus, *Sow.* (? P. Beaveri)	1	–	–	–	5	–	–	–
,, cretosus, *Defr.*	–	2	3	–	5	6	7	–
,, pexatus, *Woods*	1	–	–	–	5	6	–	–
,, (Neithea) quinquecostatus, *Sow.*	–	2	–	–	5	6	–	–
Plicatula sigillina, *Woodw.*	1	2	3	4	5	6	7	–
,, sp.	–	–	–	–	5	–	–	–
Septifer lineatus, *Goldf.*	1	2	–	4	–	6	–	–
Spondylus dutempleanus, *d'Orb.*	1	2	3	–	–	6	–	–
,, latus, *Sow.*	1	2	3	–	5	6	–	–
,, spinosus, *Sow.*	1	2	–	4	–	6	–	–
Brachiopoda.								
Crania egnabergensis, *Retz.*	–	–	–	–	5	6	7	–
,, parisiensis, *Defr.*	1	–	–	–	–	6	–	–
Kingena lima, *Defr.*	–	–	–	–	5	6		–
Rhynchonella Cuvieri, *d'Orb.*	1	–	–	–	–	–	–	–
,, limbata, *Schloth.*	–	–	–	–	–	6	7	–
,, plicatilis, *Sow.*	1	2	3	4	–	6	–	–
,, reedensis, *Eth.*	1	2	3	4	5	6	–	–
,, sp.	–	2	–	–	5	–	–	–
Terebratula carnea, *Sow.*	1	–	–	–	–	–	7	–
,, semiglobosa, *Sow.*	1	2	3	–	5	6	–	–
Terebratulina Rowei ? *Kitch.*	–	–	–	–	–	6	–	–
,, striata, *Wahl.*	1	2	–	4	5	6	–	–
,, sp.	1	–	–	–	–	–	–	–
Thecidium Wetherelli, *Morris*	–	2	–	–	–	6	–	–
Bryozoa.								
Ceriocava ramulosa, *Mich.*	–	–	3	–	–	6	–	–
Claviclausa clava, *d'Orb.*	–	–	–	4	–	6	–	–
Defrancia sp,	–	–	–	–	–	6	–	–
Idmonea (Retecava) cretacea, *Edw.*	–	–	–	–	–	6	–	–
Lunulites cretaceus, *Defr.*	–	2	–	–	–	6	–	–
Others not identified	–	–	–	4	5	6	–	–

	Zone of H. planus.	Corang. zone		Marsup. zone.		Quadratus zone.		Mucronata zone.
		Winchester.	Stockbridge.	Clanfield.	Winchester.	Hursley, &c.	Portsdown.	Portsdown.
	1	2	3	4	5	6	7	8
Crustacea.								
Pollicipes glaber, *Roemer*	1	–	–	–	–	6	–	–
" striatus, *Darw.*	–	–	–	–	–	6	–	–
" sp.	–	–	–	–	5	6	–	–
Scalpellum fossula, *Darw.*	–	–	–	–	–	6	–	–
" maximum, *Sow.*	–	–	–	–	–	6	–	–
Annelida.								
Serpula ampullacea, *Sow.*	1	2	–	4	–	6	–	–
" annulata, *Reuss*	1	–	–	–	–	6	–	–
" fluctuata, *Sow.*	–	2	–	–	5	6	–	–
" granulata, *Sow.*	1	–	3	–	5	6	–	–
" ilium, *Sow.*	–	–	–	–	–	6	–	–
" plana, *S. Woodw.*	–	2	–	–	–	–	–	–
" plexus, *Sow.*	1	2	–	4	–	6	7	–
" turbinella, *Sow.*	–	2	–	–	–	6	–	–
" sp.	–	–	–	–	–	6	7	–
Echinoidea.								
Cidaris clavigera, *König*	1	2	–	–	–	6	–	–
" hirudo, *Sorig.*	1	2	–	4	5	6	–	–
" sceptrifera, *Mant.*	1	2	3	–	–	6	–	–
" subvesiculosa, *d'Orb.*	–	–	–	–	–	–	–	–
" sp.	–	2	–	–	–	6	–	–
Cyphosoma Kœnigi, *Mant.*	–	2	–	–	5	6	–	–
" magnificum ? *Ag.*	1	–	–	–	–	–	–	–
" radiatum, *Sorig.*	–	–	–	–	–	6	–	–
" spatuliferum, *Forbes*	–	2	–	–	–	–	–	–
" sp	–	2	–	–	–	6	–	–
Echinocorys scutatus, *Leske*	1	2	3	4	5	6	7	8
Epiaster gibbus, *Lam.*	–	2	–	–	–	–	–	–
Galerites abbreviatus, *Desor*	–	2	–	–	–	–	–	–
" albogalerus, *Leske*	–	2	3	–	5	6	–	–
" globulus, *Desor*	–	–		4	–	–	–	–
" sp.	–	–	–	–	–	6	–	–
Holaster planus, *Mant.*	1	–	–	–	–	–	–	–
Micraster coranguinum, *Leske*	–	2	3	–	–	6	–	–
" corbovis, *Forbes*	1	–	–	–	–	–	–	–
" cortestudinarium, *Goldf.*	1	–	–	–	–	–	–	–
" Leskei, *Desm.*	1	–	–	–	–	–	–	–
Offaster pillula, *Lam.*	–	–	–	–	–	6	7	8
Salenia geometrica, *Ag.*	–	–	–	–	–	6	–	–
" granulosa, *Forbes*	–	–	–	–	–	6	–	–
" minima, *Ag.*	–	–	–	–	–	6	–	–

	Zone of H. planus.	Corang. zone.		Marsup. zone.		Quadratus zone.		Mucronata zone.
		Winchester.	Stockbridge.	Clanfield.	Winchester.	Hursley, &c.	Portsdown.	Portsdown.
	1	2	3	4	5	6	7	8
Asteroidea and Crinoidea.								
Bourgueticrinus ellipticus, *Miller*	–	2	–	–	5	–	7	–
,, sp.	–	–	–	–	–	–	–	–
Calliderma latum, *Forbes*	1	–	–	4	–	6	–	–
Marsupites testudinarius, *Schloth.*	–	–	–	4	5	–	–	–
Metopaster Parkinsoni, *Forbes*	–	2	–	–	–	6	–	–
,, uncatus, *Forbes*	–	–	–	–	–	6	–	–
,, sp.	–	2	–	–	–	6	–	–
Mitraster rugatus, *Forbes*	1	2	–	–	–	6	–	–
Oreaster bulbiferus, *Forbes*	–	–	–	–	5	6	–	–
Pentacrinus Agassizi, *Hag.*	1	–	–	–	–	–	–	–
Pentagonaster megaloplax, *Sladen*	–	2	–	–	–	–	–	–
Pycnaster angustatus, *Forbes*	–	2	–	–	–	6	–	–
Uintacrinus westfalicus, *Schlüt.*	–	–	–	–	5	–	–	–
Actinozoa.								
Axogaster cretacea, *Lonsd.*	–	–	–	–	–	6	–	–
Diblasus gravensis, *Lonsd.*	1	–	–	–	–	–	–	–
Onchotrochus serpentinus, *Dunc.*	–	–	–	–	–	6	–	–
Parasmilia centralis, *Mant.*	1	–	–	–	–	6	–	–
Spongida.								
Camerospongia subrotunda, *Mant.*	–	2	–	–	–	6	–	–
Cliona cretacea, *Portl.*	–	–	–	–	5	6	7	–
Porosphæra globularis, *Phil.*	1	2	–	–	5	6		–
,, pileolus, *Lam.*	–	2	–	4	5	6	–	–
,, Woodwardi, *Carter*	–	2	–	4	5	6	–	–
Ventriculites alcyonoides, *T. Smith*	1	–	–	–	–	–	–	–
,, cribrosus, *Phil.*	–	–	–	–	5	–	–	–
,, mammillaris, *T. Smith*	1	–	–	–	–	–	–	–
,, sp.	–	2	–	4	–	6	–	–
Verruculina sp.	–	–	–	–	–	6	–	–

CHAPTER VI.

THE UPPER CHALK IN SOUTH WILTSHIRE.

GENERAL DESCRIPTION.

The area occupied by the Upper Chalk in South Wiltshire is shown in the map in Volume I. of this Memoir, p. 248, whereon the outcrop of the Chalk Rock has been delineated. It will be seen that this is an extremely irregular line, running for a long distance down the valley of the Wily, and then westward till it climbs to a very high level on White Sheet Hill, north of Mere. On the northern side of the vale of Wardour the continuity of the outcrop is broken by a powerful fault, which curves south-eastward near Baverstock, and truncates the eastern end of the vale.

On the south side of the Vale of Wardour the lower beds of the Upper Chalk form the highest part of the ridge, which ends in another at White Sheet Hill, east of Shaftesbury, a ridge which separates the Vale of Wardour from the Vale of Broad Chalk. The structure of the latter is clearly shown by the mapping of the Chalk Rock, and is proved to be a succession of dome-shaped uplifts (three or four) arranged along an anticlinal axis. This axis is prolonged eastward across the valley of the Avon, and is continued in the tract of chalk which indents the boundary of the Eocene north-east of Downton.

From this anticlinal axis the Upper Chalk dips northward under what may be called the Salisbury syncline, and southward into a wider main syncline of the Hampshire basin.

It is only in the eastern part of this area, near Salisbury and Downton, that any great thickness of Upper Chalk comes in. In most other parts of the district no higher zone than that of *Micraster coranguinum* is found. In describing the local development of the several zones it will suffice to give particulars of some of the best exposures of the lower zones, and then to concentrate our attention on the neighbourhood of Salisbury.

In South Wiltshire the zone of *Holaster planus* has the true Chalk Rock aspect, always containing two or more beds of hard compact yellowish limestone with layers of green-coated nodules.

It is not often, however, that the whole of the Chalk Rock beds are exposed in one section, and a visit to some localities might lead the observer to believe that there were only a few feet of such rocks More complete sections, however, show that the harder rock beds often pass down into less hard and more nodular chalk, forming a set of beds which are from 12 to 16 feet thick. In other places the group expands by the intercalation of separate beds of lumpy chalk, some of which are hard, and others consist of hard lumps in soft mealy kind of chalk; the whole group is then from 20 to 26 feet thick, always having a hard rock-bed at the base and another at the top.

Above the uppermost bed of rocky chalk we find softer but still lumpy chalk containing many flints, and often thin seams of flint, while there are no flints in the Chalk Rock beds. These higher beds contain Micrasters of the *cortestudinarium* type, and may be referred to the zone of that species, but other fossils are few. There are few good exposures of this zone, and its upper limit has nowhere been satisfactorily fixed, but it is supposed to be 40 or 50 feet thick in the valley of the Wily.*

The succeeding zone of *Micraster coranguinum* is as usual of considerable thickness (more than 200 feet), and is believed to occupy the larger part of the surface area of Salisbury Plain; it also occupies some space west of Salisbury and north of the Vale of Wardour. Its lower beds contain many cavernous flints, often of a reddish tinge inside, its middle part black flints with a milky white band, and the upper beds grey flints with a thick white crust or rind.

The only part of South Wiltshire in which the higher zones of the Upper Chalk have been carefully studied is the neighbourhood of Salisbury. Some account of this was given in 1876 byProfessor Barrois (op. cit. pp. 54, 64). Dr. Blackmore has been collecting for many years from all the quarries within a radius of five or six miles of Salisbury, and has kindly placed the results of his labours at my disposal. I had the further advantage of visiting most of the exposures near Salisbury under his guidance in 1890. It is from these materials that the following account of the upper zones has been compiled.

What has been said respecting the different characters of the flints in the successive zones of Hampshire (see p. 57) is equally applicable to those in the Upper Chalk of Wiltshire, and special notice of the flints will be taken in the following pages.

The total thickness of Upper Chalk exposed in this district is between 700 and 750 feet. The following estimates of the thickness of the several zones are based on information communicated by Dr. Blackmore :—

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* This area was examined long before the publication of Dr. Rowe's work on the genus *Micraster*, and no attempt has yet been made to fix the limits of the lower zones in Wiltshire by means of the Micrasters.

		Feet.
Zone of Bel. mucronata - - - -	about	100
„ of Act. quadratus - - - - - -	„	270
„ of Marsupites - - - - - -	„	120
„ of M. coranguinum - - - - -	„	240
Zones of M. cortestudinarium and H. planus	„	70
	About	800

The facts on which these estimates are based are as follows all the information being communicated by Dr. Blackmore The zone of *Holaster planus* is seen to be over 20 feet thick near Homington, and 45 feet is probably a low estimate for the zone of *M. cortestudinarium*, so that the two together may be put at 70 feet.

The quarry on Camp Down, between the valleys of the Wily and the Avon, is 230 feet above the rivers; this quarry is in the zone of *M. coranguinum* and the beds are horizontal, while its base is probably at about the level of the Avon stream. Hence there is over 230 feet of this zone.

The thickness of the *Marsupites* zone is obtained by adding the thicknesses of exposures of the *Marsupites* and *Uintacrinus* bands at different places.

With respect to the *Act. quadratus* zone, two wells have been sunk between Harnham Hill and the river, through chalk with thin-skinned flints, and fossils like those at Highfield (*Marsupites* zone). From the top of the wells to the top of Harnham Hill is 170 feet.

Again N.E. of Salisbury, the fauna of the *Act. quadratus* zone occurs at a level of 260 feet. and there is no sign of the higher zone on the adjoining hill, which rises to 533 feet, so that the thickness here seems to be at least 270ft.

As to the zone of *Bel. mucronata*, a well has proved 63 feet of it, but from the space it occupies it is not likely to exceed 100 feet.

STRATIGRAPHICAL DETAILS.

1. Chalk Rock and Associated Beds.

There are many old quarries in the Chalk Rock on the Downs to the east and south-east of Warminster. In the large quarry on Warminster Down the lower rock bed (3½ feet), and 12 to 15 feet of the overlying lumpy chalk are shown, and a similar section is exposed in the quarry on Clay Hill, the outlier to the westward. On Boreham Down, 2½ miles north-east of Warminster, certain beds of chalk-rock have been quarried, which are probably the highest in the group, and entirely above those seen on Warminster

Down. Fig. 35, is a sketch of this quarry as seen in 1889, and the following is a description of the beds :—

	Ft.	in.
Thin soil with chalk rubble below - - - -	2	6
5. White chalk, rather hard, splitting into beds with a line of thin lenticular flints and a layer of large flint nodules at the base - - - - - -	3	0
4. Hard chalk-rock full of green-coated nodules and many rough flint nodules - - - - - -	0	6
3. Very hard, compact, cream-cold limestone (about 12 inches), passing down into hard nodular chalk with green grains - - - - in all about	2	9
2. Hard yellowish chalk-rock, with green-coated nodules projecting in weathered face - - - - -	1	0
1. Very hard solid rock, passing down into nodular chalk - - - - - - - seen for	2	0
	12	3

Fossils are rare, and the beds are almost horizontal.

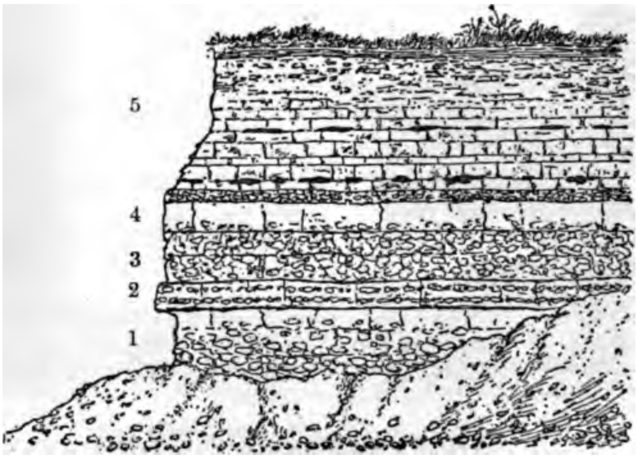

Fig. 35.—View of Quarry on Boreham Down.

The following notes are contributed by Mr. F. J. Bennett—

A quarry west of Tinker's Barn, north of Heytesbury Park, gives a similar section, showing about 7 feet of white rubbly chalk with flint nodules and a broken seam of grey flint, overlying hard cream-coloured chalk rock with layers of green-coated nodules, seen for 5 feet.

Another section, exposing 13 feet of chalk with flints, and 8 feet of yellowish rocky beds, can be seen in the yard of a barn north of Upton Lovell.

There are other exposures near Codford, Sherrington, and Wylye, but the most complete one in this valley is the quarry at Steeple Langford, about 360 yards E.N.E. of the church. I am indebted

to the Rev. W. R. Andrews, F.G.S., for the following description and for the photograph from which Fig. 36 has been drawn.

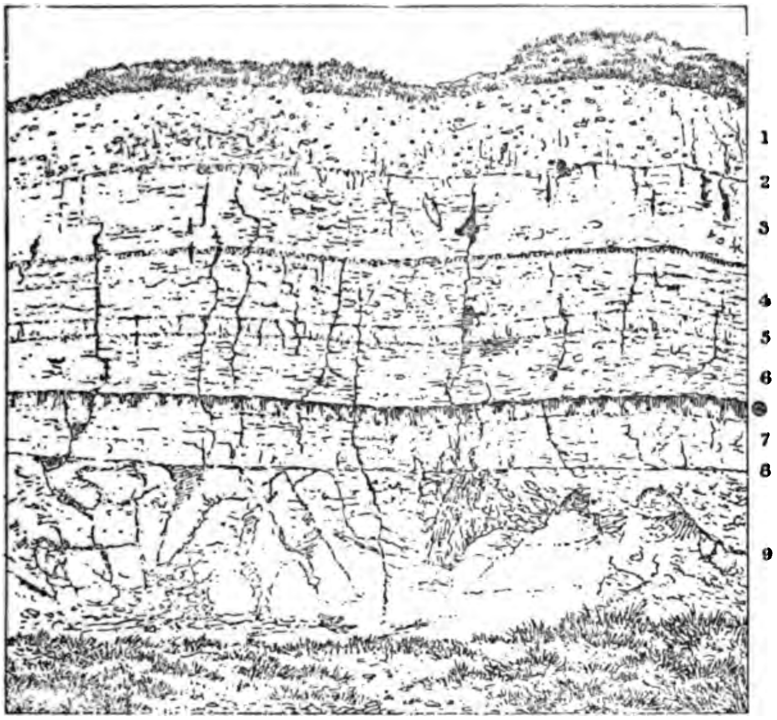

FIG. 36.—View of Quarry at Steeple Langford.

		Ft.	in.
	1 & 2. Soft white rubbly chalk with a few scattered black flints and a layer of such flints at the base	5	0
Zone of H. Planus.	3. Very hard nodular yellowish limestone, with many green-coated nodules, passing down into less hard nodular chalk	4	0
	4. Similar hard limestone with nodular chalk below	4	6
	5. Course of hard rocky chalk	1	0
	6. Rock and nodular chalk, like No. 3	4	0
	7. Rock as before, passing down into less hard nodular chalk	4	6
	8. Thin layer of grey marl	0	3
	9. Massive white chalk - seen for	6	0
	About	30	0

Nos. 8 and 9 belong to the *Terebratulina* zone. The beds of Chalk Rock here have a total thickness of 18 feet and probably represent the whole zone of *H. planus* in a locally concentrated form.

Mr. Bennett found that the upper part of the Chalk Rock was also visible in the river cliff about a quarter of a mile north-west of Wishford church, 10 feet of the rocky beds with green-coated nodules being overlain by 12 feet of nodular white chalk containing five layers of nodular flints, and three continuous layers or flint floors. These 12 feet may be referred to the zone of *M. cortestudinarium.*

A quarry just east of the cross-roads at Stapleford is probably opened in the latter zone. Mr. Bennett informs me that it is about 20 feet deep, and combining his account with that given of it by Dr. Barrois, the section, now much talused, appears to have been :—

	Feet.
Hard white chalk with a few black flints and several flint seams, *Cidaris subvesiculosa* and *Micraster cortestudinarium* ? - - - - - - - - - -	10
Hard nodular chalk with yellowish stains - - - -	3
White chalk with flints, both nodules and continuous floors, talused, but dug for - - - - - - - -	7

What appears to be the summit of this zone, and its junction with that of *M. coranguinum,* is exposed in a quarry at the north end of Wishford; the following is Dr. Barrois' account, with the thicknesses corrected by Mr. Bennett :—

	Feet.
Soft white chalk with many layers of flints and several flint seams, also joints filled with flint. *Echinocorys gibbus* and *Micraster coranguinum* - - - - - - - -	15
Hard yellowish nodular chalk - - - - - - - -	½
Rather hard chalk with scattered flints - - - - -	6

Chalk which may be in or at the top of the same zone is exposed also in the valley of the Avon between Lower and Upper Woodford. At Middle Woodford there is a large pit which has been described by Dr. Barrois ("Recherches," p. 53), and of which I took the following notes in 1890 :—

	Feet.
Soft white chalk with many layers of flint nodules, and some large masses of flint - - - - - - - - -	24
Hard yellowish nodular chalk with marked plane of division at top - - - - - - - - - - - - - - -	2
Hard yellowish nodular chalk, with nodular upper surface, enclosing many flints of irregular shapes and often hollow, with *Doryderma ramosum* - - - - - - - -	2
Softer white chalk with numerous flints and a seam of continuous flint - - - - - - - - - - -	10

The beds are nearly level, with a slight inclination to the south. Fossils are fairly abundant, and from the nodular beds and the underlying chalk I obtained *Micraster præcursor*, *Cidaris clavigera* (spines), *Echinocorys gibbus*, *Terebratula semiglobosa*, and *Rhynchonella reedensis.* Mr. Bennett afterwards obtained a specimen of *Coscinopora infundibuliformis.* It is possible that the upper beds may belong to the zone of *Micraster coranguinum,* in which case the higher bed of nodular chalk may be regarded as the top of the zone of *M. cortestudinarium.*

From Wishford the outcrop of the Chalk Rock runs westward along the southern side of Wily Valley, in and out of the combes which open into that valley, as far as Boyton (see Map in the first Volume of this Memoir, opposite p. 248). Thence it passes westward to the Valley of the Deverill, and a good section is exposed in a quarry at Kingston Deverill, for the following particulars of which I am indebted to Mr. J. Scanes, of Maiden Bradley :—

	Feet.
White nodular chalk with a layer of brown clay at the base	6½
Chalk Rock, in regular beds from 12 to 18 inches thick, each having a layer of green-coated nodules at the top - -	7

Another good series of sections in the zones of *Holaster planus* and *Micraster cortestudinarium* can be found along the north border of the Vale of Wardour from Mere to Barford.

The Chalk rock beds are quarried on Mere Down at a height of about 650 feet about a mile north of Mere. The quarry shows 14 feet of rough nodular chalk resting on beds of hard Chalk Rock, seen for nearly 3 feet, with two layers of green-coated nodules. From the nodular beds Mr. Scanes obtained and sent to me the following species: *Ptychodus latissimus*, *Inoceramus Cuvieri*, *Spondylus spinosus*, *Terebratula semiglobosa*, *Micraster Leskei*, *M. præcursor*, and *Echinocorys scutatus* (pyramidal variety).

Thence the outcrop of the rock-beds descends steadily and rather rapidly till it runs down to the great fault line at a height of a little over 400 feet near West Knoyle.

A good section, bringing a considerable thickness of beds into a small space because of the high dip on the south side of the fault, occurs in a pit by the road side, near Chapel Farm, north of Upton. The descending succession seen by me in 1890 was as follows :—

		Feet.
Zone of Micr. cortest.	Hard white chalk with many layers of flint nodules, large and small and of irregular shapes - - -	20
	Hard white chalk with three continuous seams of flints - - - - - - - - - - - -	2
Zone of *Hol. planus.*	Hard rough yellowish rock, passing down into rough gritty chalk - - - - - - - - - -	1½
	Hard nodular chalk with a few flints, many *Micrasters* - - - - - - - - about	20
	Hard chalk-rock with two layers of green-coated nodules, forming a ridge in the pit floor - - -	3
	About	46

A good section of the zones of *Holaster planus* and *Terebratulina* is visible in a quarry by the side of the road from East Knoyle to Hindon. The beds shown here are :—

		Feet.
	White chalk with many flints and several thin seams or floors of flint - - - - - - - - - - - - -	9
Zone of *H. planus.*	Rough yellowish nodular sandy chalk, with green grains and a few flint nodules - - - -	1½
	Hard gritty nodular chalk, a seam of yellow-coated nodules at the top, and others less well marked below; no flints - - - - - - - -	12
	Hard yellowish chalk-rock with layers of green-coated nodules, breaks into massive blocks - -	3½

Terebratulina zone.	Firm white chalk in thick beds - - - about	50
	Greenish marly seam.	
	Hard cream-coloured chalk, probably the top of the zone of *Rhynch. Cuvieri* - - - - - -	2
		75

Fossils are not abundant, but *Micraster præcursor* occurs in the nodular chalk.

Another section by the tunnel, south-east of Hindon, shows how the beds alter in a short distance. This is as follows :—

	Feet.
Tough white chalk with a few flints - - - - - -	8
Hard yellowish rock (1½ feet) passing down into hard nodular chalk with green grains - - - - - - - -	3½
Hard yellowish rock passing down into greyish nodular chalk with two subsidiary layers of rock ; green grains -	6
Hard yellowish rock (1 foot) passing down into hard lumpy whiter chalk - - - - - - - - seen for	5

This is probably the upper part of the *H. planus* zone, here assuming the "Chalk Rock" character throughout.

From this point eastward, the zone of *Hol. planus* is only occasionally seen in small exposures ; At the eastern end of the Vale, however, on the upthrow side of the fault, the Chalk Rock beds are well exposed in the railway cutting at Barford. The descending section taken by me about 90 yards from the west end of the cutting is as follows :—

	Ft.	*in.*
Hard lumpy chalk with scattered nodules of black flint, very gritty and yellowish in some places (? zone of *M. cortestudinarium*) - - - - - - - - - -	12	0
Hard and heavy nodular limestone with yellow stains, in two layers, the upper full of green-coated nodules -	1	3
Hard yellowish limestone passing down into hard rough nodular chalk - - - - - - - - -	3	4
Parting of white shaly chalk.		
Hard nodular chalk - - - - - - - -	1	3
Hard yellowish limestone with a layer of green-coated nodules at top, passing down into rough lumpy chalk. *Ter. carnea* and *Micraster præcursor* - - - -	7	0
Soft yellowish-grey marl - - - - - -	0	3
Rough nodular chalk with yellow stains, very hard in places : some fossils - - - - - - - -	4	6
Parting of buff shaly marl.		
Nodular white chalk with two layers of grey sandy and shaly chalk - - - - - - - - -	4	6
Hard nodular limestone with a layer of green-coated nodules, probably the bottom bed of Chalk-rock *Micraster corbovis* and *Ter. semiglobosa* - seen for	3	0
	37	1

It will be seen that the zone of *Holaster planus* or Chalk Rock has here a thickness of over 25 feet. The thickness of the overlying lumpy chalk is uncertain, but in the cutting east of the bridge 5 feet of it are seen overlain by soft white chalk with four continuous layers of flint, and as the upper rock bed occurs at the base of this cutting there is probably from 15 to 16 feet of the lumpy chalk between, containing Micrasters of the *cortestudinarium* type.

Part of the same set of beds is exposed on the south side of the valley in the road cutting at the head of the "Punch Bowl," near Burcombe. Here the upper beds are much weathered, but the junction with the zone below is clearly exposed, the section seen in 1890 being as below:—

		Ft.	*in.*
Zone of *Hol. planus* (26 feet).	Hard compact yellow limestone - - -	1	6
	Hard rough nodular chalk - - -	10	0
	Layer of soft marl.		
	Hard rough nodular chalk with yellow stains -	6	0
	Tough gritty whitish chalk, splitting into flattish lumps with lenticular seams of greyish marl - - - - - - - about	5	0
	Hard nodular rock with two layers of green-coated nodules; passes into next - - -	3	6
Zone of *Terebratulina.*	Tough and lumpy white chalk - - - -	5	0
	Seam of light grey marl - - - - -	0	4
	Bedded white chalk - - - - seen for	3	0

This section, therefore, gives the base-line, which is wanting to complete that of the Barford cutting, and shows the full thickness of the *Hol. planus* zone to be just 26 feet.

The rocky beds of the *H. planus* zone are seen in several of the roadways which ascend the fine escarpment along the southern side of the Vale of Wardour, as, for instance, in the roads south of Compton and of Fovant, a pit by the latter exposing 11 or 12 feet of them.

Passing to the Vale of Broad Chalk by way of Compton Down the outcrop is again passed through about three-quarters of a mile north of the village. Here Dr. Barrois noted 30 feet of hard nodular chalk overlying a bed of chalk-rock with green-coated nodules, and from the former obtained the following fossils:—

Micraster cortestudinarium.
„ corbovis ?
Inoceramus Cuvieri ?
Terebratula semiglobosa.

Mr. Bennett informs me it is also exposed in a quarry west of Prescombe Farm, north-west of Broad Chalk.

It is also fairly well shown in the road cutting north-east of Homington, where the hard, yellowish basement rock is seen to dip northward at about 8 deg., and to be overlain by about 20 feet of nodular rock, with some scattered flints and another hard bed at the top. There is another exposure by the roadside, south of Homington, from which Dr. Blackmore has obtained the following species:—

Inoceramus.
Ostrea vesicularis.
Spondylus spinosus.
Terebratulina lata ?
„ striata.
Terebratula semiglobosa.
Rhynchonella reedensis.
Holaster planus.
Micraster Leskei.
Parasmilia centralis.

2. The Upper Chalk near Salisbury.

Zone of Micraster coranguinum.

The quarry at Middle Woodford, north of Salisbury, has been described on p. 74, and the probability of its being opened at the junction of the zones of *M. cortestudinarium* and *M. coranguinum* was then mentioned. There is a small pit at Little Durnford,on the eastern bank of the Avon, which exposes chalk with many layers of thin-skinned flints, most of them stained red or reddish with iron oxide; this is certainly in the zone of *Micraster coranguinum*, that fossil and *Echinocorys scutatus* being common here.

A pit at the north end of the village of Stratford shows some 25 feet of firm but brittle white chalk, with layers of flints at intervals of from 1 to 3 feet; these flints have thin skins, and many are cavernous, the hollows showing traces of *Doryderma ramosum*, and some having drusy cavities filled with quartz crystals. Several layers, however, consist of solid flints stained red or brown by iron. *Micraster coranguinum*, *Galerites albogalerus*, *Cidaris hirudo*, *Ostrea semiplana*, *Inoceramus Cuvieri*, and other fossils have been found here.

On Camp Down, between the valleys of the Avon and the Wily, there is a large pit near the main road showing 25 to 30 feet of chalk with similar thick-rinded flints, many of them showing pink, white, and grey bandings, and being of very irregular shapes with knobby or cornute projections. Fossils are scarce, but twenty species have been found by Dr. Blackmore and Mr. G. Westlake, and prove it to be in the *M. coranguinum* chalk, though it must be near the top of that zone.

The zone of *Micraster coranguinum* probably occupies a large part of the surface of Salisbury Plain, and is deeply trenched by the rivers which traverse that plain. West of Salisbury it also occupies some space round Quidhampton, Wilton, and Netherhampton.

At Quidhampton there is a large pit on the north side of the railway showing between 50 and 60 feet of chalk. Flints occur in regular courses, which are from only about 2 feet apart in the upper 40 feet, but more distant in the lower part; most of them have very thin rinds, some hardly anything but a white skin, but a few have a definite white crust; some are large, with irregular knobby surfaces. The bedding is nearly horizontal. From the lower beds I obtained *Micraster coranguinum*, *Epiaster gibbus*, *Terebratula carnea*, *Inoceramus Cuvieri*, *Lima Hoperi*, and *Ostrea vesicularis*, and Dr. Blackmore has found a few other species. (See list, p. 84 *et seq.*)

The higher part of the zone is exposed in a pit by the Roman road south of Netherhampton. When seen in 1890 much of it was hidden by talus, but the chalk exposed contains numerous flints like those at Camp Down; the flints have the same pink and white chalcedonic layers in the outer crust. Some of the usual fossils of the zone have been found here.

South-west of Salisbury, in the valley of the Chalk river, a portion of the central part of the zone is exposed a little south of Odstock, dipping to the north at about 9°. The chalk is firm, white and brittle; flints occur in frequent layers about 2 feet apart and nearly all of them have a band or zone of cloudy white flint a little distance beneath the surface. Fragments of a large *Inoceramus* are common, but other fossils are rare.

In ascending Clearbury Hill from Charlton a definite succession of beds may be recognised from the characters of the flints seen in small pits and roadside banks. Thus a quarry opposite Charlton Farm is about 30 feet deep in rather hard chalk, with many solid plain black and dark grey flints, and fragments of *Inoceramus* shells are abundant. A pit about a quarter-mile to the south-west shows about 16 feet of chalk, containing layers crowded with irregular shaped flints about 2 feet apart, and most of them have the cloudy white zone above mentioned, but some are stained red or pink by iron. Higher up on Clearbury flints with the same cloudy band are seen, but near the top of the hill they have thick crusts like those at Camp Down.

A quarry in the lower part of this zone, north of Ufford, shows some interesting features; it is about 20 feet deep in well-bedded chalk, which shows a dip of about 2° to the south-east. The descending succession is as follows:—

	Ft.	*in.*
Chalk, inaccessible	8	0
Continuous seam or floor of flint	0	1
Firm solid chalk without flints	2	0
Soft loose marly chalk crowded with flints	1	0
Solid bedded chalk, with few flints	4	0
Soft marly chalk	0	6
Chalk with many scattered flints	8	0
	23	6

The beds are broken by a small fault with an oblique hade and a throw of about 4½ feet. The flints, both large and small, have either a thin crust or none at all. Fossils found were *Micraster coranguinum*, *Galerites albogalerus*, and *Inoceramus involutus*.

The upper part of the *M. coranguinum* chalk is exposed in the railway cutting at Witherington, north of Downton, and the beds which correspond with those at Camp Hill dip at 14° to the south, and there are other exposures on the eastern side of the Avon. On the western side of that river its basset surface must occupy a considerable tract of country south of the Broad Chalk valley.

Zone of Marsupites.

The chalk of this zone is exposed at several places, and both the *Uintacrinus* and the *Marsupites* bands have been located by Dr. Blackmore.

What is probably the lowest part of the *Uintacrinus* band is exposed in a pit on the northern side of Old Sarum hill, the chalk is soft, with a few scattered flints not in layers. These flints have thick rinds which are banded in layers of white and grey, and are solid throughout; the smaller nodules have in fact only a small nucleus of clear black flint, but both the black and the white parts are equally hard. From 12 to 15ft. is seen, and Dr. Blackmore has obtained *Uintacrinus* and other fossils.

The higher part of this band is well shown in the quarry at the whiting-works at Highfield (Fisherton); this is about 50 feet deep in soft white chalk; flints are not numerous, but occur sparsely along planes which are about 10 feet apart. Most of them are nearly spherical, from the size of bullets to that of cannon balls, are yellow outside, but have no crust, merely the yellow stain, and consist wholly of solid black flint. The workmen state that they have quarried about 12 feet below the pit floor, and found the same kind of chalk, but the flints have a white rind. *Actinocamax verus*, small *Kingena lima*, and the ovate variety of *Echinocorys scutatus* are common here. Remains of *Uintacrinus* have been found, and twenty-five specimens of *Ammonites* [*Haploceras*] *leptophyllus*, with other fossils (see p. 84). A single plate of *Marsupites* was obtained from the top of the pit, and doubtless marks the base of the *Marsupites* band.

The *Marsupites* band was exposed in the cutting west of the tunnel on the L. & S.W. railway north of Salisbury at a level of about 220 feet. It is also seen in a pit on Bishops Down just half a mile to the northward, at a height of from 280 to 300 feet above O.D. This shows soft white chalk, with more numerous flints, all having thick white crusts. Plates of *Marsupites* and joints of *Bourgueticrinus* are very abundant at this locality, and a specimen of *Am.* [*Hapl.*] *leptophyllus* about 2 feet in diameter was found in 1893. Thus we may estimate the *Uintacrinus* band at about 70 feet, and the *Marsupites* band at about 50 feet, making a total of 120 feet from the zone. Dr. Blackmore informs me that in 1893, a well was sunk at the Salisbury Waterworks which are north of the town, at a level of 200 feet, and just south of the railway cutting, in which plates of *Marsupites* were abundant. Yet the well, which is 70 feet deep, traversed chalk with occasional layers of flints exactly like those of Highfield. The first layer met with was 45 feet from the surface, and one *Marsupite* plate was found in the lower 30 feet. In spite of this occurrence he believes the chalk to belong to the *Uintacrinus* band, and is inclined to suppose that a line of fault runs between the Waterworks and the cutting.

Zone of Actinocamax quadratus.

The zone of *A. quadratus* forms the high ground to the east and north-east of Salisbury, and also the ridge which lies to the south of the villages of East and West Harnham. It consists of chalk, in which flints are rather more numerous than in the *Marsupites* zone, and in the lower part of it *Offaster pillula* is the most common fossil.

At East Harnham there is a fine quarry worked in two levels. The lower one shows about 50 feet of bedded white chalk, with only a few scattered flints; the upper level shows about 60 feet, with seven or eight layers of flints at varying distances, sometimes 6 feet, sometimes 10 or 12 feet apart, with only a few scattered flints in the intervening chalk. The beds are regular, and dip at about 2° to the south, unbroken by faults. The flints have white crusts, but not thick ones, and are all solid. Fossils are not abundant, but through the workmen Dr. Blackmore has obtained many species from this pit (see p. 83 *et seq.*)

At West Harnham there is another large quarry from 60 to 70 feet deep. In the higher part the chalk is regularly bedded; in the lower part the bedding is less distinct, and it is probably a lower portion of the zone, for the flints, few and scattered, are stained yellow outside. *Act. granulatus* is fairly common in the upper part, but rare in the lower beds, though it has been found in them.

At Britford a quarry shows about 30 feet of the higher beds, consisting of bedded chalk, with layers of flints at intervals of about 3 feet, and sometimes less.

East of Salisbury there is a small exposure of the lower part of the zone at the cross-roads east of Milford, but, though only 10 or 12 feet of chalk are exposed, many specimens of *Offaster pillula* can at any time be obtained, with joints of *Bourgueticrinus* and a small *Rhynchonella* (*? reedensis*); the shelly plates which are usually regarded as the aptychi of *Am.* [*Haploceras*] *leptophyllus* and *Am.* [*Pachydiscus*] *Portlocki*, and which Dr. Blackmore regards as shelly processes belonging to the guards of *Belemnitella lanceolata* and *Actinocamax quadratus*,* have been found here as well as at the Harnham quarries, and are certainly as common in this zone as are the two characteristic Belemnites.

Part of the same zone, with flints like those of Harnham, is exposed in the railway at Ashley Hill, and in the pit below the level of the railway, north of Ashley Hill House. Dr. Blackmore has also traced the zone at intervals for some distance to the north-east, and has found a piece of *Act. granulatus* thrown out of a rabbit hole on the hill known as Thorny Bushes.

South-east of Salisbury there is a good section of the zone in the railway cutting at Whaddon, which shows soft white chalk, with irregular layers and scattered nodules of flint, and occasional seams of soft marly chalk dipping to the north at about 14°. The flints have thicker white crusts than those of Harnham but there is the same assemblage of fossils. A quarry in the field near the railway is about 15 feet deep in similar chalk.

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* See Geol. Mag., Dec. 4, Vol. III., p. 529 (1896).

At West Grinstead, south of the brickyard, there is another pit in similar chalk dipping at 16° to the north. It contains, however, regular layers of flints at 3 or 4 feet apart, many of the nodules being large and smooth, with rounded protuberances; they have thick crusts, often pink and agaty, like those of Camp Down. Fossils did not appear common, but I found *Act. granulatus.*

Zone of Belemnitella mucronata.

This, the highest zone of the chalk in the Hampshire basin, is only found round the border of the area occupied by the Lower Eocene to the east and south-east of Salisbury. Its junction with the underlying zone is exposed in the railway cutting, about 1½ miles S.E. of Salisbury, close to the north end of the bridge, over the road to Clarendon Park. The junction is approximately marked by a thin layer of yellow stained chalk, above which *Bel. mucronata* comes in. This zone is also exposed in a chalk-pit at Shootend, north-west of Alderbury, between the branching of the roads to Downton and to Southampton. The chalk here seen is very soft and white, with few flints, those that occur consisting of solid black flint without any crust—merely a yellow coating. *Belemnitella mucronata* is fairly common, with *Echinocorys scutatus, Terebratula carnea, Rhynchonella limbata,* a large variety of *Kingena lima,* and other fossils similar to those found in the Norwich chalk. More recently Dr. Blackmore has found *Magas pumilus* and pieces of an Ammonite which seems to be *Am.* [*Lytoceras*] *Jukesi.*

Dr. Blackmore also informs me that in 1893 a well was sunk on the Southampton road above Shootend and a little beyond the second milestone from Salisbury; it passed through—

	Feet.
Clay and Sand - - - - - - - - - - -	12
Chalk of the *Bel. mucronata* zone - - - - -	63

and many fossils were obtained from the chalk which was brought up, including five examples of *Bel. mucronata.*

Still further east, near Clarendon, there are some pits in this zone. One near the keeper's house in Clarendon woods is about 10 feet deep in soft white brittle chalk, with a few scattered flints, which often occur on one plane, but at distances of 2 or 3 feet from one another. The flints here differ from those at Shootend in having an ordinary white crust, but just the same assemblage of fossils is found. There is another pit in similar chalk near the Clarendon brickyard, and here the beds show a dip of 3° to the east.

The zone of *Bel. mucronata* is also exposed in two chalk pits at Breamore further east, and Mr. Jebbett, the station-master there has obtained fossils from them.

List of Fossils from the Upper Chalk near Salisbury.

The following list is probably the most complete local catalogue of Upper Chalk fossils which has hitherto been published, and for it I am indebted to the kindness of Dr. Blackmore. Not only has he collected carefully from all the exposures of the chalk round Salisbury, but he has kept separate lists of the fossils obtained from every exposure, so that each place was eventually assignable to its proper zone as the collection of its fossils progressed. The localities which I have tabulated are only those which have proved the most fossiliferous, and which suffice to give a full list of the fossils which have been obtained from each zone.

The Reptile and Fish remains have been submitted to and named by Dr. A. S. Woodward, of the British Museum. Mr. G. C. Crick has identified the *Actinocamax Toucasi*, a species not before recorded in this country; it much resembles the *Act. plenus* of the Lower Chalk. The Lamellibranchs have been named by Dr. Blackmore by comparison with the figures published by the best authorities, but some corrections and additions have recently been made by Mr. H. Woods.

The Bryozoa were all examined and named by the late Mr. Vine, but no doubt the nomenclature will require some modification when Dr. Gregory's catalogue is completed.

Of the Crustacea it may be mentioned that of the five species of *Scalpellum*, three, viz., *darwinianum*, *quadricarinatum*, and *semiporcatum*, have not hitherto been recorded as British.

The Echinodermata have been identified chiefly by the aid of Dr. Wright's Monograph on the *Echinoidea* and Mr. Sladen's on the Asteroidea, published by the Palæontographical Society.

The corals have been examined and named by Mr. Robert F. Tomes.

For the zone of *Holaster planus* the locality is near Homington.

For that of *Micraster cortestudinarium* Middle Woodford is the only locality.

For that of *Micr. coranguinum* the chief localities are Camp Hill (1), Porton railway cutting (2), Quidhampton (3), Stratford (4), and Witherington cutting (5).

For that of *Marsupites* there are two localities—Highfield (6) and Bishopdown (7).

For that of *Actinocamax quadratus* the chief localities are the two large quarries at Harnham (8), Britford (9), and Whaddon cutting (10).

For that of *Belemnitella mucronata* there are three localities—Shootend, near Alderbury (11), Clarendon (12), and a cutting on the L. and S. W. Railway (13).

	Zone of Hol. planus.	Zone of M. cortest.	Zone of Micraster coranguinum.	Zone of Marsupites.	Zone of Act. quadratus.	Zone of Bel. mucronata.
Reptilia.						
Leiodon anceps, *Owen*	–	–	2	–	8	–
Pachyrhizodus gracilis, *Owen*	–	–	–	–	8	–
Plesiosaurus	–	–	–	6	8	–
Pisces.						
Ancistrodon	–	–	2, 5	6	8, 10	12
Cestracion canaliculatus, *Eg.*	–	–	–	–	8	–
Cimolichthys lewesiensis, *Leidy*	–	–	–	6	8, 9, 10	11, 12
Corax affinis, *Ag.*	–	–	2	–	–	–
„ heterodon, *Reuss*	–	–	–	6	8, 10	13
„ maximus, *Ag.*	–	–	–	–	10	–
Enchodus lewesiensis, *Mant.*	–	–	5	6	8	–
„ serratus? *Eg.*	–	–	–	6	8	–
Galeocerdo Jaekeli, *A. S. Woodw.*	–	–	–	6	8	–
Lamna appendiculata, *Ag.*	–	–	2, 5	6	8, 10	12
„ macrorhiza, *Cope*	–	–	5	6	8, 10	–
„ serra, *A. S. Woodw.*	–	–	–	–	8	–
Notidanus microdon, *Ag.*	–	–	–	6	8	–
Oxyrhina crassidens, *Ag.*	–	–	–	–	8	–
„ Mantelli, *Ag.*	–	–	3	6	8, 10	–
Protosphyræna ferox, *Leidy*	–	–	2, 5	–	8	–
Ptychodus decurrens, *Ag.*	–	–	–	–	8	–
„ mammillaris, *Ag.*	x	–	–	–	–	–
„ polygyrus, *Ag.*	–	–	2	6	–	–
Scapanorhynchus raphiodon, *Ag.*	–	–	5	6	8, 10	–
„ subulatus, *Ag.*	–	–	–	–	8, 10	–
Scylliodus antiqnus, *Ag.*	–	–	2	6	8, 10	–
Cephalopoda.						
Ammonites [Lytoceras] Jukesi, *Sharpe*	–	–	–	–	–	11, 12
„ [Haploceras] leptophyllus, *Sharpe*	–	–	–	6, 7	–	–
Aptychus leptophyllus, *Sharpe*	–	–	–	–	8, 10	–
„ Portlocki, *Sharpe*	–	–	–	–	8, 9, 10	–
„ rugosus, *Sharpe*	–	–	–	–	–	11, 12
Actinocamax quadratus, *Defr.*	–	–	–	–	8, 9, 10	–
„ granulatus, *Mayer*	–	–	–	–	8, 9	–
„ Toucasi, *Janet*	–	–	1, 5	6	8	–
„ verus, *Miller*	–	–	–	–	–	–
Belemnitella lanceolata, *Schloth.*	–	–	–	–	8, 10	–
„ mucronata, *Schloth.*	–	–	–	–	–	11, 12, 13
Rhyncholites	–	–	–	–	8	–
Gasteropoda.						
Aporrhais sp.	–	–	–	–	–	12
Dentalium planicostatum, *Héb.*	–	–	–	–	–	11, 12, 13
Hipponyx sp.	–	–	1	–	8	12
Pleurotomaria perspectiva, *Mant.*	–	–	2	–	–	–
Lamellibranchiata.						
Avicula tenuicosta, *Roemer*	–	–	–	–	8	–
„ sp. nov.	–	–	–	–	8	12
Inoceramus Brongniarti, *Sow.*	–	–	–	–	8, 9	–
„ Cuvieri, *Sow.*	x	–	5	–	–	11, 12
„ digitatus, *Sow.*	–	–	2	–	8	–
„ involutus, *Sow.*	–	–	3, 4	–	–	–
„ Lamarcki, *Park.*	–	–	2	–	–	–
„ latus, *Mant.* (non *d'Orb.*)	–	–	2	–	8, 10	–
„ sp.	x	x	–	–	–	–
Lima granosa, *Sow.*	–	–	–	–	8, 9, 10	11, 12, 13
„ Hoperi, *Sow.*	–	–	1, 2, 3, 5	6	8	–
„ læviuscula, *Sow.*	–	–	1	6	8, 10	–
„ pectinata, *d'Orb.*	–	–	–	6	8	–
„ semisulcata, *Nilss.*	–	–	–	–	–	11, 12
„ „ var. dutempleana, *d'Orb.*	–	–	–	–	–	12
„ sp.	–	–	–	–	10	12
Ostrea canaliculata, *Sow.*	–	–	1, 5	6	8, 9, 10	–
„ curvirostris, *Nilss.*	–	–	–	–	8, 9, 10	–
„ hippopodium, *Nilss.*	–	–	2, 3, 5	6, 7	10	–
„ *lateralis* (*see* canaliculata)						
„ larva, *Lam.*	–	–	–	6	8, 9, 10	–
„ normaniana, *d'Orb.*	–	–	3	6, 7	–	–
„ semiplana, *Sow.*	–	–	4	6, 7	8, 9, 10	11, 12, 13
„ sulcata, *Blum.*	–	x	–	–	8, 9	12
„ vesicularis, *Lam.*	x	–	–	6, 7	8, 9, 10	11, 12
„ virgata, *Sow.*	–	–	–	–	8	–
„ wegmanniana, *d'Orb.*	–	–	5	6	–	–
„ sp. nov.	–	–	–	–	8	–

	Zone of Hol. planus.	Zone of M. cortest.	Zone of Micraster coranguinum.	Zone of Marsupites.	Zone of Act. quadratus.	Zone of Bel. mucronata.
Pecten britannicus, *Woods*	–	–	4	–	–	–
„ campaniensis, *d'Orb.*	–	–	–	7	8	12
„ concentricus, *S. Woodw.*	–	–	–	–	–	11, 12
„ Nilssoni, *Goldf.*	–	–	–	–	8	–
„ cretosus, *Defr.* (=nitidus, *Mant.*)	–	–	1, 2, 5	6, 7	8, 9, 10	–
„ pexatus, *Woods*	–	–	–	–	8	–
„ sarumensis, *Woods*	–	–	–	–	8	–
„ (Hinnites) sp	–	–	–	–	8	–
„ (Neithea) Dutemplei, *d'Orb.*	–	–	–	–	8, 10	–
„ „ quadricostata, *Sow.*	–	–	–	–	–	–
„ „ quinquecostata, *Sow.*	–	–	–	–	8	12
Pinna decussata, *Sow.*	–	–	–	–	8	–
Plicatula sigillina, *S. P. Woodw.*	x	x	1, 2, 3, 4, 5	6. 7	8, 9, 10	11, 12
„ sp.	–	–	–	–	8	11, 12
Septifer lineatus, *Sow.*	–	–	–	–	8	11
Spondylus dutempleanus, *d'Orb.*	–	x	–	–	8, 9, 10	12
„ latus, *Sow.*	–	–	1, 3, 4, 5	6, 7	8, 9, 10	11, 12
„ serratus, *Woods.*	–	–	–	6	–	–
„ spinosus, *Sow.*	x	x	1, 2, 3, 4, 5	6	8	–
Tellina royana, *d'Orb.*	–	–	–	–	8, 10	12
Teredo amphisbæna, *Goldf.*	–	–	–	6	–	–
Brachiopoda.						
Crania egnabergensis, *Retz.*	–	–	–	–	8, 10	–
„ „ var. costata, *Sow.*	–	–	–	–	–	11, 12, 13
„ parisiensis. *Defr.*	–	–	4	6	8, 9, 10	11, 12
Kingena lima, *Defr.*	–	–	5	6, 7	8, 9, 10	11, 12, 13
Magas pumilus, *Sow.*	–	–	–	–	9	11, 12
Rhynchonella limbata, *Schloth.*	–	–	–	–	9, 10	11, 12
„ plicatilis, *Sow.*	–	–	5	6	8, 9, 10	11, 12
„ „ var. octoplicata, *Sow.*	–	–	5	–	8, 9, 10	–
„ „ var. Woodwardi, *Dav.*	–	–	1	6	–	–
„ reedensis, *Eth.*	x	x	1, 4, 5	6, 7	8, 9, 10	11, 12, 13
Terebratula carnea, *Sow.*	–	–	3	–	–	11, 12
„ obesa, *Sow.*	–	–	1	–	–	–
„ semiglobosa, *Sow.*	x	x	–	–	8	–
Terebratulina gracilis (? Rowei, *Kitchin*)	–	–	4	–	8, 10	–
„ lata ? *Eth.*	x	–	–	–	–	–
„ striata, *Wahl.*	x	–	1, 3, 4	6, 7	8, 9, 10	11, 12, 13
Thecidium Wetherelli, *Morris*	–	–	1, 2, 5	6	–	11, 12
Bryozoa.						
Many (*see* General List).						
Crustacea.						
Astaciform crustacean	–	–	–	–	8	12
Pollicipes Angelini, *Darw.*	–	–	–	–	10	–
„ fallax, *Darw.*	–	–	–	–	–	12
„ glaber. *Roemer.*	–	–	–	–	8, 10	–
„ striatus, *Darw.*	–	–	4, 5	–	8	–
„ sp.	–	–	–	–	8	11
Scalpellum darwinianum, *Bosq.*	–	–	–	–	8	12
„ fossula, *Darw.*	–	–	–	–	8, 10	12
„ maximum, *Sow.*	–	–	–	6	8, 10	11, 12, 13
„ quadricarinatum, *Reuss.*	–	–	–	–	8, 10	–
„ semiporcatum, *Darw.*	–	–	–	–	8	11, 12
Annelida.						
Ditrupa difformis, *Lam.* (=Serp. septemsulcata)	–	–	–	–	8	11, 12, 13
Serpula ampullacea, *Sow.*	–	–	2	6	8, 9	12, 13
„ annulata. *Reuss.*	–	–	–	6	8, 9	12
„ plexus, *Sow.*	–	–	2, 5	6, 7	–	12
Echinodermata.						
Bourgueticrinus ellipticus, *Miller*	–	–	1, 3, 4, 5	6	8, 9, 10	12
„ „ var. æqualis	–	–	–	–	8, 9, 10	–
„ sp.	–	–	–	6, 7	–	–
Cardiaster ananchytis, *Leske*	–	–	–	–	–	12
„ *pillula* (*see* Offaster).						
Cidaris clavigera, *König*	–	x	1, 2, 3, 4	–	–	–
„ hirudo *Sorig.*	–	–	2, 4, 5	6	8, 9, 10	11, 12
„ perornata, *Forbes*	–	–	2	–	–	–
„ sceptrifera, *Mant.*	–	–	1, 2, 5	6	–	–
„ subvesiculosa, *d'Orb.*	–	–	1	–	8	–
Cyphosoma corollare, *Klein*		–	2, 5	6	8	–
„ Kœnigi, *Mant.*		–	1, 2	–	–	–
„ radiatum, *Sorig.*			2, 5	–	8, 9, 10	11, 12

	Zone of Hol. planus.	Zone of M. cortest.	Zone of Micraster coranguinum.	Zone of Marsupites.	Zone of Act. quadratus.	Zone of Bel. mucronata.
Cyphosoma spatuliferum, *Forbes*	–	–	–	–	8	–
Discoidea sp.	–	–	–	–	8	–
Echinocorys scutatus, var. gibbus, *Lam.*	x	x	3, 4	–	8, 9, 10	–
„ „ var. ovatus, *Leske*	–	–	1, 3, 4, 5	6, 7	–	11 12
Galerites albogalerus, *Leske*	–	–	1, 2, 3, 4, 5	6, 7	–	–
Goniaster (*see* Metopaster, Mitraster, &c)						
Helicodiadema fragilis, *Wiltshire*	–	–	–	–	8, 9, 10	12
Holaster planus, *Mant.*	x	–	–	–	–	–
Infulaster excentricus, *Forbes*	–	–	–	–	8, 10	–
„ rostratus, *Forbes* (Hagenovia)	–	–	–	6	8	–
Marsupites testudinarius, *Schloth.*	–	–	–	6, 7	–	–
Metopaster Bowerbanki, *Forbes*	–	–	–	–	8	–
„ Mantelli, *Forbes*	–	x	4	–	–	12
„ Parkinsoni, *Forbes*	–	–	1, 4	6	8, 10	12
„ uncatus, *Forbes*	–	–	2	6	8	12
„ sp. nov.	–	–	–	–	8	–
Micraster coranguinum, *Leske*	–	–	1,2,3,4,5	–	–	–
„ cortestudinarium, *Goldf.*	–	x	–	–	–	–
„ præcursor, *Rowe*	x	x	–	–	–	–
Mitraster Hunteri, *Forbes*	–	–	2	–	–	–
„ rugatus, *Forbes*	–	–	2, 4	–	–	–
Nymphaster marginatus, *Sladen*	–	–	–	–	8	–
„ oligoplax, *Sladen*	–	–	–	6	8	–
Offaster pillula, *Lam.*	–	–	–	6	8, 9, 10	–
Oreaster Boysi, *Forbes*	–	–	–	–	8	–
„ bulbiferus, *Forbes*	–	–	–	6	8, 10	–
„ obtusus, *Forbes*	–	x	–	–	8	12
„ ocellatus, *Forbes*	–	–	–	6	8, 10	–
Pentagonaster lunatus, *S. Woodw.*	–	–	–	–	–	12, 13
„ megaloplax, *Sladen*	–	–	1, 3, 4	6	8, 9, 10	–
Pycnaster angustatus, *Forbes*	–	–	–	6	8, 10	11, 12, 13
Salenia geometrica, *Ag.*	–	–	–	–	8, 10	12
„ granulosa, *Forbes*	–	–	–	–	8	–
„ magnifica, *Wright*	–	–	–	–	8	–
„ minima, *Ag.*	–	–	–	–	8	–
„ (spines)	–	–	–	–	–	12
Uintacrinus westfalicus ? *Schlüt.*	–	–	–	6	–	–
Actinozoa.						
Axogaster cretacea, *Lonsd.*	–	–	–	7	–	–
Caryophyllia cylindracea, *Reuss*	–	–	5	6	–	–
Cœlosmilia laxa, *E. & H.*	–	–	–	–	8	11, 12
„ regularis, *Tomes*	–	–	–	–	8	–
Diblasus gravensis, *Lonsd.*	–	–	–	–	8, 10	–
Onchotrochus serpentinus, *Dunc.*	–	–	–	–	–	12
Parasmilia centralis, *Mant.*	x	–	5	6	8, 10	11, 12
„ „ var. gravesiana, *E. & H.*	–	–	–	–	8	–
„ „ var. Mantelli, *E. & H.*	–	–	–	–	8	11, 12
„ serpentina, *E. & H.*	–	–	5	–	–	–
Spinopora Dixoni, *Lonsd.*	–	–	–	6, 7	8	–
Stephanophyllia numismalis, *Tomes*	–	–	–	–	8	–
Spongida.						
Coscinopora infundibuliformis, *Goldf.*	–	x	–	–	–	–
Doryderma ramosum, *Mant.*	–	x	–	–	–	–
Porosphæra globularis, *Phil.*	–	x	1, 2, 5	6, 7	8, 9, 10	11, 12, 13
„ pileolus, *Lam.*	–	–	–	6	8, 9	11, 12
„ **Woodwardi, *Carter***	–	–	5	–	8, 9	13
Spongia (?)	–	–	–	6	9	12, 13
Ventriculites	–	–	1, 4	6, 7	8, 9	11, 12, 13
Wood (drifted)	–	–	1	–	–	–

CHAPTER VII.

THE UPPER CHALK IN THE ISLE OF WIGHT.

General Description.

The first attempt to recognise the zones of the Upper Chalk in the Isle of Wight was made by Professor Barrois, in 1875,* but in this he only distinguished two zones above that of *Micraster cortestudinarium*, these being the zone of *M. coranguinum* and the zone of *Belemnitella*.

In his later publication† Professor Barrois makes some corrections; he transfers a part of his *M. cortestudinarium* zone to that of *M. coranguinum*, and remarks that what he had called the *M. coranguinum* zone includes that of *Marsupites*. He also states in his original description that his "zone *à Belemnitelles*" corresponds to the zones which are known in France under the names of zone of *Actinocamax quadratus* and zone of *Bel. mucronata*. He had, therefore, practically divided the Upper Chalk or Senonian into zones, though he had not followed them in detail across the island, nor had he attempted to estimate the thickness of them severally.

No one has since attempted to make a zonal examination of the Upper Chalk of the island, and unquestionably the task is not easy, for though there are numerous pits along the outcrop of the beds the angle of dip is so high that there are not many pits in any one zone; and again, though this part of the Chalk is exposed in fine cliff sections at each end of the island, they cannot be approached on foot, and the waves break against them for the greater part of their length.

My friend Mr. W. Hill visited some of the chalk-pits along the chalk ridge in 1897, and discovered *Marsupites* in the quarry on Arreton Down. We supposed at the time that this was the first actual discovery of the remains of *Marsupites* in the island, but subsequently found that their existence was known to Mr. Ch. Griffith, of Winchester; further, that he and Mr. R. M. Brydone had visited nearly all the quarries in the Upper Chalk, collecting extensively from the several zones. They will, I trust, soon publish the results of their researches, but meantime they have most kindly placed their lists at my disposal as well as some notes respecting the zones exposed in certain quarries.

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* Description géologique de la craie de l'Ile de Wight. Bibl. des Hautes Etudes (St. Nat.) Tom. xiii. 1875, with coloured map.

† Recherches sur le Terrain Crét. Sup, p. 107 (1876).

With respect to the base of the Upper Chalk in the Isle of Wight we have already stated (Vol. II., p. 410) that we cannot regard the layer of green-coated nodules as the equivalent of the Chalk Rock, nor can we even take the seam of dark grey or nearly black marl, which occurs some 7 or 8 feet higher, as the base of the *H. planus* zone; for that fossil is not common in the intervening chalk, nor is it associated with many Micrasters for another 8 or 9 feet, when there occurs a similar seam of light-grey marl. Above this marl the Micrasters begin to come in (both *M. Leskei* and *M. præcursor*), and a little higher *Echinocorys scutatus* is met with. As this marl band seems to be continuous across the island we take it as a convenient plane for the base of the Upper Chalk, although it may be really a few feet below the real palæontological limit.

With regard to the thickness of the Upper Chalk as a whole, several estimates have been made. Professor Barrois' estimates give a total thickness of 290 metres (950 feet), including his zone of *M. cortestudinarium*, but he undoubtedly allowed too small a thickness for the "zone *à Belemnitelles.*"

Mr. Strahan estimated the total thickness of chalk above the "Chalk-rock" nodules at 1,350 feet, but we consider this to be rather too high an estimate.

It is well known that along the central ridge of the island the strata of the Chalk are bent over, till they pitch beneath the Eocene at very high angles, generally from 75° to 85°; consequently they can only be measured by plotting sections to scale, and calculating the thickness between a prolongation of the curves. Four such sections have been drawn, and published in Sheet 47 of the Horizontal Sections of the Geological Survey (new edition, 1889); an examination of these shows that in each of the first two sections the thickness between the supposèd horizon of the Chalk Rock and the Eocene is about 1,250 feet. The section through Ashey Down shows too much disturbance for accurate measurement, and that through Bembridge Down gives only 1,075 feet, due either to local compression or possibly to some small error in the engraving.

Hence I regard the sections through Brook and through St. George's Down as giving the most trustworthy results, and adopt 1,250 feet as the thickness of the Chalk between the horizon, above mentioned. To get the thickness of the Upper Chalk as understood in this volume we must deduct from this amount the thickness of chalk between the nodule bed and the base of the *Holaster planus* zone, about 16 feet, which leaves about 1 236 feet. This agrees closely with a section drawn by me through Arreton Down (see Fig. 37), which shows about 1,240 feet in the same space. This thickness may be assigned to the four zones on the following proportions.

	Feet.
Zone of *Bel. mucronata*	300
„ „ *Act. quadratus*	400
„ „ *Marsupites*	150
„ „ *Micr. coranguinum*	300
„ „ „ *cortestudinarium and Hol. planus*	90
	1,240

STRATIGRAPHICAL DETAILS.

Zones of Holaster planus and M. cortestudinarium.

Above the seam of grey marl, which we have taken as the top of the zone of *Terebratulina* there are six or seven feet of hard nodular or knotty chalk without flints. Above this comes a variable thickness of nodular chalk with flints, in which fossils are abundant. The upper part consists principally of hard homogeneous chalk with many flints, and some continuous flint seams; occasionally also there are layers of nodular chalk; in these beds fossils are less common than below. The lower nodular beds vary from 20 to 30 feet in thickness, and the higher part probably from 30 to 40, but we have not attempted to separate the two zones or to fix the summit of the *M. cortestudinarium* zone anywhere in the island.

Only the lower portion can be examined at Culver, where it appears to be as follows, when clear of falls from the cliff:—

		Feet.
Upper Chalk	Chalk with grey flints.	
	Smooth chalk with *Holaster planus* - - -	4
	Nodular chalk splitting along dark wavy lines - -	3
	Seam of grey marl - - - - - -	*an inch.*
Middle Chalk.	Nodular chalk as above - - - - - - -	10
	Seam of dark clay.	

A portion of the zone is exposed in a quarry half a mile west-north-west of Yarbridge, and the section has been given by Mr. Strahan, his account, with slight verbal alteration, being reproduced below, but the beds are grouped in accordance with our view of the zonal limits:—

		Ft.	in.
Upper Chalk.	Chalk with a few flints, grey inside - - - -	8	0
	Rough nodular chalk with yellowish lumps; fossiliferous in the lower part - - - - -	6	0
Middle Chalk.	Seam of white marl - - - - - - -	0	1
	Rough nodular chalk - - - - - -	8	0
	Seam of black clay - - - - - - -	0	1
	Rough chalk passing down into smoother chalk	8	0
	Layer of green coated nodules - - - - -	0	1
	Rough nodular chalk - - - - - -	2	6
	Smooth chalk, - - - - - - seen for	5	6
		38	3

In the quarry east of Carisbrook Castle there are 12½ feet of nodular chalk without flints, overlain by a few feet of nodular chalk with scattered grey flints.

The section in the quarry on Brixton Down has been mentioned in Vol. II., p. 412. It is a good exposure, showing about 21 feet of rough nodular chalk without flints above the clay band succeeded by 20 feet of less nodular chalk with flints; the chalk here is so hard, and has been subject to so much squeezing, that the fossils cannot be detached in good condition for identification. A similar section however is seen in a quarry at the south-east corner of Shalcombe Down, and from thence Mr. Rhodes obtained some of the fossils included in the list on p. 95.

The most accessible and complete section in these beds is that exposed in the road cutting on Afton Down. This was described and figured by Dr. Barrois, and some of the beds were subsequently measured by Mr. Strahan, but he did not carry his account into the flint-bearing chalk. We give a diagrammatic view based on Dr. Barrois' sketch (Fig. 37) and the vertical succession may be stated as follows:—

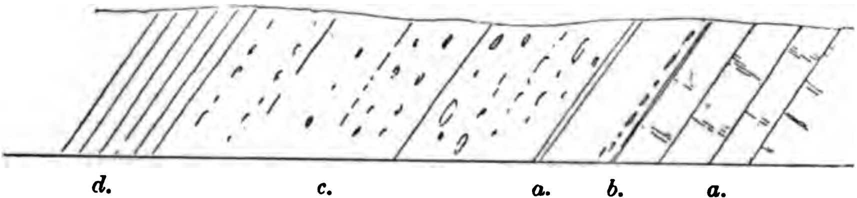

FIG. 37.—Sketch of Section in Military Road, Afton Down.
a, a—*Terebratulina* Zone. *b*—layer of green coated nodules. *c, d*—Zones of *Hol. planus* and *M. cortestudinarium.*

		Ft.	in.
Upper Chalk.	Chalk with regular layers of flints - - -	?30	0
	Hard chalk with scattered flints and occasional nodular beds - - - - - - about	40	0
	Nodular chalk without flints - - - - -	7	0
Middle Chalk.	Layer of whitish marl - - - - -	0	1
	Hard nodular chalk - - - - - - - -	8	0
	Black marly clay - - - - - - -	0	1
	Nodular chalk - - - - - - - - -	6	0
	Hard chalk with a layer of green-coated nodules at the top - - - - - - - - -	1	6
	Massive chalk with layers of marl, seen for -	60	0

It will be noticed that the portion without flints is here reduced to 10 feet, but we are not sure whether this reduction is not more apparent than real; it may be that flints occur here in beds which at Culver are without flints.

Hard nodular chalk, containing typical *Micraster cortestudinarium,* occurs also at the headland on the west side of Freshwater Bay, accessible at low tide.

Zone of Micraster coranguinum.

At the western end of the island this zone occupies the cliffs from Scratchalls Bay, south of the Needles, to Freshwater Bay; but as far as Watcombe Bay, near Freshwater, these cliffs are only accessible by boat on a calm day. Mr. Whitaker, writing in 1865,* says, "the parallel layers of flint are very frequent, many quite continuous, some of a peculiar brown or pinkish tint, and all more or less broken up. At Sun Corner, the southern horn of Scratchalls Bay, there is a bed of some thickness, in which the layers of flint are so close together that they form nearly as much of the rock as the chalk itself. . . . It is shown in Fig. 38, in which the black lines represent the layers of flint."

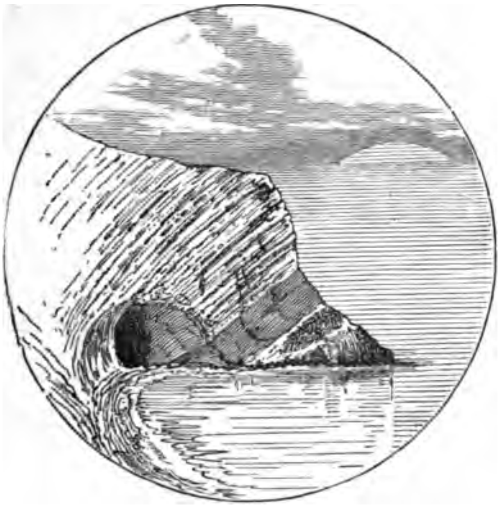

FIG. 38—Scratchalls Bay, looking southward, showing frequent layers of flints; from a photograph.

The lower part of the *M. coranguinum* zone is accessible on foot in Watcombe Bay and on the west side of Freshwater Bay, and from these localities Messrs. Griffith and Brydone have collected many of its fossils, as well as from five or six pits along the top of the cliffs between Freshwater and Scratchalls Bay.

Prof. Barrois refers to this zone the chalk seen in a small pit north-west of Bowcombe Wood near Carisbrooke, from which he obtained *Micraster coranguinum*, *Galerites albogalerus* and a *Spondylus*. If in this zone it must be in quite the lowest part of it.

Mr. Griffith writes that the large pit half a mile east of Carisbrooke may be in this zone, but that fossils are very scarce, and the evidence is not decisive. Mr. Hill is also inclined to refer the chalk here to the upper part of the *M. coranguinum* zone.

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* Quart. Journ. Geol. Soc., vol. xxi., p. 401.

The highest beds of the zone and its passage up into that of *Marsupites* may be seen in a large quarry at the west end of Arreton Down (Downend pit).

Mr. Griffith is also disposed to regard the upper quarry northwest of Yarbridge by the road leading on to Brading Down as exposing the chalk of this zone.

The zone of Marsupites.

Marsupites have up to the present been found only at two places in the island, one a small exposure near Freshwater, discovered by Mr. Griffith, the other being in the large quarry on Arreton Down above mentioned. Fig. 112 is a section through this quarry showing the position of the band of chalk, which is characterised by the presence of *Marsupites* and the scarcity of flints.

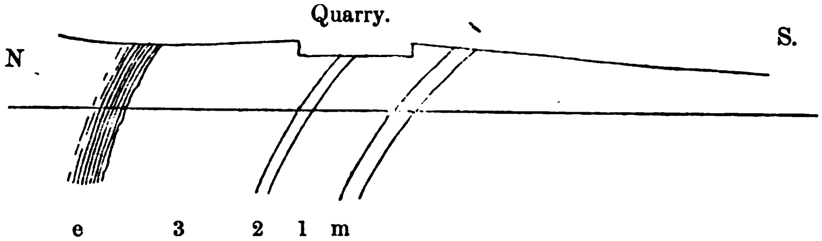

FIG. 39.—Section through the chalk-pit on Arreton Down. Scale. horizontal and vertical, 6 inches to a mile.

e = Eocene
3 = Zones of Act. quadratus. and Bel. mucronata
2 = Zone of Marsupites.
1 = Zone of M. coranguinum.
m = Middle Chalk.

The following details of the succession of beds forming this zone were taken by Mr. Hill at this quarry in descending order:—

		Ft.	*in.*
Zone of *A. quadratus.*	Chalk with regular layers of flints; thickness not measured - - - - -probably about	80	0
	Hard white chalk with two continuous seams of flint - - - - - - - - -	6	0
Zone of *Marsupites*, about 150 feet.	Hard white chalk with layer of flints at base -	3	0
	Hard white chalk without flints, massive beds with a marl seam in the centre; *Actinocamax granulatus* - - - - - - - -	15	0
	Layer of flints - - - - - - - -	0	3
	White chalk with a few scattered flints near the base - - - - - - - - -	5	6
	White chalk with a few flints arranged sparsely along lines - - - - - - - -	19	0
	Thin seam of marl - - - - - - -	0	2
	Chalk with a few flints thinly scattered along definite lines - - - - - - - -	18	0
	White chalk with flints as above, contains *Marsupites*, *Offaster pillula*, *Rhynchonella plicatilis*, and other fossils - - -about	20	0
	White chalk with occasional lines of flints, these becoming more numerous below - -about	70	0

Chalk with layers of close-set flints (zone of *M. coranguinum*).

The beds are dipping to the north at about 40 deg. Besides single plates Mr. Hill found a complete test of *Marsupites testudinarius* here. For the fossils which Messrs. Griffith and Brydone have obtained here, see list on p. 95.

In Culver cliff the flintless chalk of this zone was observed by Mr. Whitaker so long since as 1865, his notice of it being as follows:—"Here in the midst of the chalk, with layers of flint at every 3 or 4 feet, is a space some 40 or 50 feet thick with only one thin seam of tabular flint, but with four lines of green-coated nodules like those of the Chalk Rock, but perhaps of a deeper colour." Referring to this band, Mr. Strahan says it is from 350 to 400 feet above the so-called Chalk Rock, *i.e.*, the nodules in the *Terebratulina* zone, and that from one of the nodule beds were obtained *Offaster pillula*, *Serpula plexus*, *Rhynchonella plicatilis*, a coral and a sponge.

Zone of Actinocamax quadratus.

Above the Marsupite zone there seems to be a great thickness of chalk (300 feet or more), in which *Act. quadratus* occasionally occurs, and in which *Offaster pillula* is sometimes common. Certain pits, which are presumably at the summit of the zone, yield examples both of *Act. quadratus* and of *Bel. mucronata*, an association which is rare in other parts of England.

For the following notes on the pits which Messrs. Griffith and Brydone refer to this zone I am indebted to Mr. Griffith.

The new fort above the Needles seems to be situated on it; they found numerous specimens of *Offaster pillula* in the excavations for the foundations, and its position is too northerly for the *Marsupites* zone.

A pit at Freshwater Gate by the pumping station yielded *Act. quadratus* and *Bel. mucronata*, the latter abundantly. The same two fossils are found in the large pit east of the station at Shide, near Newport, where the beds dip northward at 75°.

The northern face of Downend pit (Arreton Down) exposes the lower part of this zone—chalk with layers of black flints.

They have also found *Act. quadratus* with *Offaster pillula* in the northern part of the Culver Cliff.

Zone of Belemnitella mucronata.

Prof. Barrois describes the chalk of this zone as soft and friable containing flints which are generally of a smoky-grey colour, but sometimes black flints, as at Alvington and Mottistone. He also remarks that *Magas pumilus* is very common in this zone, but is rare in that of *Act. quadratus*.

A line of old quarries from which some fossils may be obtained occur to the north of Afton Down.

A large quarry at Shalcombe, north of Brook, is open in this zone, dipping at a high angle to the north. .Prof, Barrois says the lower beds contain large black flints and yielded *Belemnitella mucronata*, *Echinocorys gibbus*, and *Inoceramus Cripsi* (? species); while the upper beds contain grey flints and afforded *Bel. mucronata* with *Magas pumilus*.

There are quarries on the north side of Mottistone Down, one south-east of Newbarn and another at Pitt's Farm, in all of which *Bel. mucronata* has been found.

From an old pit (now a garden) by Mord Cottage, at the west end of Carisbrooke, Mr. Hill obtained *Magas pumilus* and part of a Belemnite (? *B. mucronata*). There is also an old quarry by the main road south of Alvington Farm, from which Prof. Barrois obtained a few fossils.

The occurrence of *B. mucronata* in the large quarry between Carisbrooke and Shide has been noticed above.

Prof. Barrois records it from Mersly Down, and there is a large quarry on the north-west side of this down by Chalkpit Copse where the chalk dips at 85 degrees to the north. Probably this was the exposure he found.

There are also pits near the Eocene border north of Ashey Down and of Nunwell Down, which are doubtless in this zone.

Mr. Mark Norman has recorded *Bel. mucronata*, *Echinocorys vulgaris*, and *Galerites albogalerus* from the chalk just below the base of the Eocene in Whitecliff Bay.*

FOSSILS FROM THE UPPER CHALK OF THE ISLE OF WIGHT.

That we are able to give a completely zonified list of fossils from the Upper Chalk of the island is mainly due to the careful collecting of Messrs. Ch. Griffith and R. M. Brydone, and to their kindness in placing their results at our disposal. We have incorporated the fossils recorded by Professor Barrois in his account of the island above mentioned, and also those obtained from the zone of *Holaster planus* by the Geological Survey.

—	Zones of *M. cortest.* and *Hol. planus.*	Zone of *M. coranguinum.*	Zone of *Marsupites.*	Zone of *Act. quadratus.*	Zone of *Bel. mucronata.*
Pisces.					
Corax heterodon, *Reuss*	x	–	–	–	–
Enchodus lewesiensis, *Ag.*	–	–	–	–	x
Lamna appendiculata, *Ag.*	x	–	–	x	–
Cephalopoda.					
Aptychus rugosus, *Sharpe*	–	–	–	–	x
„ sp.	–	–	–	–	x
Actinocamax quadratus, *Defr.*	–	–	–	x	–
„ granulatus *Blainv.*	–	–	x	–	–

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* See Proc. Geol. Assoc., Vol. i., p. 40 (1865).

	Zones of *M. cortest.* and *Hol. planus.*	Zone of *M. coranguinum.*	Zone of *Marsupites.*	Zone of *Act. quadratus.*	Zone of *Bel. mucronata.*
Belemnitella lanceolata, *Schloth.*	–	–	–	–	x
,, mucronata, *Schloth*	–	–	–	x	x
Rhynchoteuthis sp.	–	–	–	–	x
Lamellibranchiata.					
Caprotina sp.	x	–	–	–	–
Inoceramus sp.	x	x	x	x	x
Lima Hoperi, *Sow.*	x	–	–	–	–
,, pectinata, *d'Orb.*	x	x	–	x	x
,, semisulcata, *Nilss.*	x	–	–	–	–
Ostrea curvirostris, *Sow.*	–	–	x	x	x
,, canaliculata, *Sow.*	x	x	x	–	x
,, hippopodium, *Nilss.*	–	–	–	x	x
,, normaniana, *d'Orb.*	x	–	–	–	–
,, semiplana, *Sow.*	x	–	–	–	–
,, vesicularis, *Lam.*	x	x	x	x	x
,, wegmanniana, *d'Orb.*	–	x	x	–	–
Pecten cretosus, *Defr.* (=nitidus, *Mant.*)	–	x	–	x	x
,, sp.	–	x	–	–	–
,, (Neithea) Dutemplei, *d'Orb.*	–	x	–	x	x
,, ,, quinquecostatus, *Sow.*	x	x	–	x	x
Plicatula sigillina, *S. P. Woodw*	x	–	–	x	x
Spondylus dutempleanus, *d'Orb.*	x	x	–	–	–
,, latus, *Sow.*	x	x	–	x	x
,, spinosus, *Sow.*	x	x	x	x	x
,, sp.	x	x	–	–	
Brachiopoda.					
Crania egnabergensis, *Retz.*	x	x	–	x	x
Magas pumilus, *Sow.*	–	–	–	–	x
Rhynchonella limbata, *Schloth.*		–	–	–	x
,, plicatilis, *Sow.*	x	x	x	x	x
,, reedensis, *Eth.*	x	x	x	x	x
Terebratula carnea, *Sow.*	x	x	–	–	x
,, semiglobosa, *Sow.*	x	x	–	x	x
,, sexradiata, *Sow.*	–	x	–	x	x
Terebratulina striata, *Wahl.*	x	x	–	x	x
,, gracilis, *Schloth.*	x	–	–	–	–
Thecidium Wetherelli, *Morris*	x	–	–	–	–
Bryozoa.					
Ceriocava ramulosa, *Mich.*	–	x	–	x	–
Claviclausa globulosa *d'Orb.* (Ceriopora)	–	x	–	–	–
Lunulites cretaceus *Defr.*	–	x	–	x	–
Cirripedia and Annelida.					
Pollicipes glaber, *Roemer.*	x	–	–	–	x
,, sp.	–	x	–	–	–
Scalpellum semiporcatum, *Darw.*	x	–	–	–	x
Serpula ampullacea, *Sow.*	x	x	–	x	x
,, annulata, *Reuss*	–	x	–	–	–

—	Zones of *M. cortest.* and *Hol. planus.*	Zone of *M. coranguinum.*	Zone of *Marsupites.*	Zone of *Act. quadratus.*	Zone of *Bel. mucronata.*
Serpula fluctuata, *Sow.*	x	x	—	x	x
„ granulata, *Sow.*	—	x	—	x	--
„ ilium, *Sow.*	x	x	—	x	x
„ plexus, *Sow.*	x	x	s	x	x
„ turbinella, *Sow.*	—	x	—	x	x
Echinodermata.					
Bourgueticrinus sp.	x	x	x	x	x
Calliderma sp.	—	x	x	-	-
Cardiaster sp.	—	x	—	—	-
Cidaris clavigera, *König*	x	x	—	x	-
„ hirudo, *Sorig.*	—	x	x	—	x
„ perornata, *Forbes*	x	x	—	—	—
„ sceptrifera, *Mant.*	x	x	—	—	x
„ subvesiculosa, *d'Orb.*	x	x	—	—	—
Cyphosoma Kœnigi, *Mant.*	—	x	—	x	—
„ radiatum, *Sorig.*	x	x	—	—	—
„ sp.	x	x	x	x	—
Echinocorys scutatus, *Leske*	x	x	x	x	x
Galerites albogalerus. *Leske*	—	x	x	x	—
„ sp.	—	x	—	—	—
Holaster planus, *Mant.*	x	—	—	—	—
Marsupites testudinarius, *Schloth.*	—	—	x	—	—
Infulaster major, ? *Desor.*	x	—	—	—	—
Micraster coranguinum, *Leske*	—	x	x	—	—
„ cortestudinarium, *Goldf.*	x	—	—	—	—
„ Leskei ? *Desm.*	x	—	—	—	—
„ præcursor, *Rowe*	x	—	—	—	..
Metopaster Parkinsoni, *Forbes*	—	—	—	—	x
Offaster pillula, *Lam.*	—	—	s	x	x
Pentacrinus Agassizi, *Hag.*	x	—	—	—	—
Salenia granulosa, *Forbes*	x	—	—	x	—
Actinozoa.					
Axogaster cretacea, *Lonsd.*	-	—	—	x	x
Parasmilia centralis, *Mant.*	x	—	—	x	x
Trochosmilia sp.	—	—	—	—	x
Spongida.					
Cephalites sp.	—	—	—	—	x
Cliona cretacea, *Portl.*	—	x	—	—	—
Plocoscyphia sp.	x	--	—	—	—
Porosphæra globularis, *Phil.*	x	x	x	x	x
„ pileolus, *Lam.* (= urceolata)	x	x	—	x	—
„ Woodwardi, *Carter*	x	x	x	x	x
Ventriculites moniliferus, *Roemer*	x	—	—	—	—
„ sp.	x	—	x	—	—

CHAPTER VIII.

THE UPPER CHALK IN SOUTH DORSET.

General Description.

The chalk of South Dorset is a continuation of that of the Isle of Wight, with which island it was doubtless once united. Brought up by a prolongation of the same uplift, the Upper Chalk is exposed at many places along the coast between Ballard cliff (near Swanage) and White Nothe (Ringstead). It is, however, so faulted, broken, and crushed that few of the sections afford satisfactory views of the zonal succession.

Professor Barrois was the first to attempt a determination of zones in this area, and more recently Dr. A. W. Rowe has published an account of the coast sections which adds very largely to our knowledge of the zonal divisions.* I shall take the latter as the basis of the following description, adding a brief account of the chalk round Dorchester from my own notes.

As stated under the description of the Middle Chalk, we agree with Dr. Rowe in thinking that the base of the zone of *Holaster planus*, and, therefore, of the Upper Chalk, as now understood, has not been accurately fixed by previous observers. We think that both Professor Barrois† and Mr. Strahan‡ have placed it too low, and that the double layer of green-coated nodules, which occurs in all exposures and has been regarded as representing the Chalk Rock, is really a nodule bed in the *Terebratulina* zone.

With respect to the thickness of the Upper Chalk in South Dorset, Mr. Strahan estimates the total thickness of Chalk on the south side of the thrust-fault, near Ballard Point, to be 1,175 feet; deducting from this the thickness of the Lower and Middle Chalk (about 250 feet) we have 925 feet left for the thickness of the Upper Chalk. As this does not include the highest beds, which are only found on the north side of the fault, we must add a certain thickness, say about 200 feet, for them, and thus obtain a total of not less than 1,100 feet. From sections plotted near Lulworth and White Nothe Mr. Strahan has estimated the thickness of Upper Chalk in that district at 956 feet, but this does not include all of the *Bel. mucronata* zone. Dr. Rowe's measurements as given below make up a total thickness of 1,060 feet.

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* Proc. Geol. Assoc., Vol. XVII, pp. 1-76, plates i-x, (1901).

† Recherches sur le Terrain Crétacé Supérieur, pp. 78-102.

‡ Geology of the Isle of Purbeck and Weymouth, Mem. Geol. Survey, 1898, p. 167 *et seq.*

We may, therefore, consider the thickness of the Upper Chalk along the southern side of the Eocene tract in Dorset to be from 1,000 to 1,100 feet, which is not far from its estimated thickness in the Isle of Wight.

From Dr. Rowe's descriptions the following may be taken as the average thicknesses of the several zones in South Dorset, at places where they have been least affected by faulting and compression:—

	Feet.
Zone of *Bel. mucronata*	250
Zone of *Act. quadratus*	350
Zone of *Marsupites*	110
Zone of *Micr. coranguinum*	230
Zone of *Micr. cortestudinarium*	50 to 70
Zone of *Hol. planus*	40 to 50
	1,060

For an account of the faults and disturbances by which the Upper Chalk of this region is affected the reader is referred to the chapter on that subject in Mr. Strahan's memoir on the Geology of the Isle of Purbeck and Weymouth.

Instead of following each zone separately, it will be more convenient to describe what is seen of the Upper Chalk at each of the principal localities, these being four (1) that of the cliffs between Studland Bay and Swanage Bay; (2) between Arish Mell and Mupe Bay ; (3) at and west of Durdle Cove ; (4) near White Nothe.

STRATIGRAPHICAL DETAILS.

THE COAST SECTIONS.

1.—The Cliffs north of Swanage.

The cliffs north of Swanage, from Ballard Point to Studland Bay, present a fine section of the Upper Chalk, though only a small part of it is accessible without a boat. The zonal succession was briefly indicated by Prof. Barrois in 1876, and has been more completely described by Dr. A. W. Rowe. The section Fig. 40, is based on that drawn by Mr. Strahan and published in the Memoir on the Isle of Purbeck, with the zonal details inserted from the diagrammatic section in Dr. Rowe's paper (Op. cit. p. 32).

Zone of Holaster planus.—This is regarded as beginning about 20 feet above the layer of green-coated nodules in the *Terebratulina* zone (*see* Vol. II.), and it is included in the chalk which Prof. Barrois referred to the zone of *M. cortestudinarium.* Dr. Rowe found it impossible to get onto any surface of the *H. planus* zone even from a boat, for the beds are vertical and form the front of Ballard Point. Its thickness is probably about 40 feet. Flints are numerous, as in the Isle of Wight.

Zone of Micraster cortestudinarium.—Dr. Rowe mentions a cave on the south side of the point from which he obtained *Micrasters* of the forms characterising this zone. As regards thickness he refers to Prof. Barrois' estimate of the *M. cortestudinarium* chalk at this place (82 feet) and says about half that thickness would in his opinion be more correct. As I feel sure that Prof. Barrois' estimate really included the zone of *H. planus,* we may assume that the true zone of *M. cortestudinarium* is here from 40 to 50 feet thick.

Zone of Micraster coranguinum.—Dr. Rowe thinks this comes into the northern side of the cave above mentioned and extends northwards for some distance, reaching to a bay which is backed by a shingle beach. No measurement is possible.

Zone of Marsupites.—About one-sixth of the distance along the cliffs of this bay he found plates of *Uintacrinus* and farther on plates of *Marsupites* in white chalk with fewer layers of flints, but no complete measurements were taken.

Zone of Actinocamax quadratus.—Dr. Rowe writes: "We then pass to a yellower and flintier chalk, which extends as far as Argyle Point. This point is drawn on the 6-inch map but is not named. . . . At the northern end of this we traced two yellow nodular bands which run out almost due east as a ledge terminating in a rock. These bands are strangely reminiscent of the 'Chalk Rock' of the Geological Survey." It would be interesting to compare these nodular layers with those which occur in the Isle of Wight, either in this zone or in that of *Marsupites* (*see* p. 93).

Dr. Rowe found two examples of *Act. quadratus* or *Act. granulatus* in or near these nodular layers, but could not obtain any other fossils either here or in the next little bay. Beyond this the base of the cliffs is much obscured by seaweed, but at a point 39 feet from the plane of the great thrust-fault which describes such a beautiful curve through the cliff, he found a good specimen of *Belemnitella mucronata,* proving that the zone of *Act. quadratus* does not extend up to the fault.

Mr. Strahan describes all the Upper Chalk on this side of the fault as "hardened into a limestone which can only be scratched with a knife, while the whole cliff is traversed by veins of calcite and innumerable planes of slickensides." Of the great fault itself, he says that it "forms a very sharp line, curving upwards in the cliff with beautiful regularity and keeping exactly parallel to the bedding-planes of the beds above it. These strata curve up through nearly an eighth of a circle, so as to be nearly vertical in the top of the cliff, while at the foot of the cliff they dip northwards at an angle of about 40 degrees. Through the whole curve they rest upon the edges of vertical chalk with a curiously close imitation of a great unconformity." (*Op. cit.* p. 169.)

Zone of Belemnitella mucronata.—It appears that Prof. Barrois was mistaken in supposing the chalk of the cliffs on the

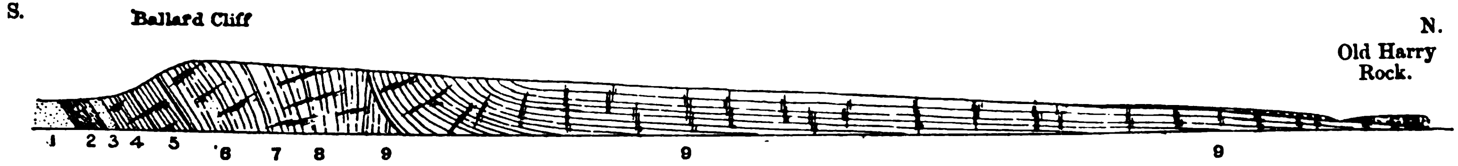

FIG. 40.—View of the Cliffs from Punfield Cove to Studland Bay. By Mr. A. Strahan.
Horizontal Scale, 6 inches to one mile. Vertical Scale, 800 feet to an inch.

9. Zone of *Bel. mucronata.*
8. Zones of *Act. quadratus* and *Marsupites.*
7. Zone of *Micraster coranguinum.*
6. Zones of *M. cortest.* and *Hol. planus.*
5. The Middle Chalk.
4. The Lower Chalk.
2. and 3. The Selbornian.
1. The Vectian (Lower Greensand).

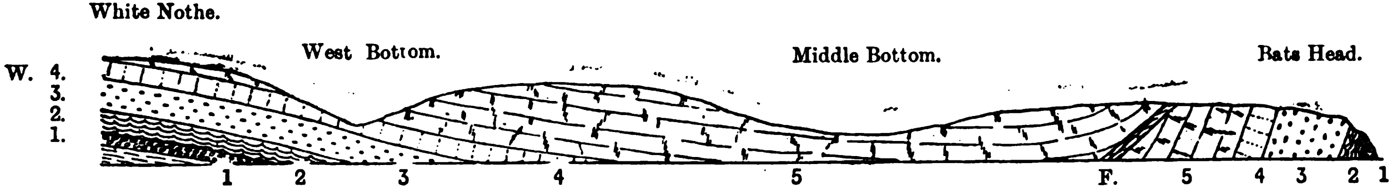

FIG. 41.—View of the Cliffs from White Nothe to Bats Head. Drawn from the data given by Dr. Rowe.
Horizontal Scale, 6 inches to one mile. Vertical Scale, 800 feet to an inch.

5. Zone of *Actinocamax quadratus.*
4. Zone of *Marsupites testudinarinus.*
3. Zone of *Micraster coranguinum.*
2. Zone of *Micraster cortestudinarium.*
1. Zone of *Holaster planus.*
F. Probable position of fault.

north side of the fault to belong to his zone of *Marsupites*. He does not mention any fossils, and seems to have been led to this conclusion by the comparative fewness of flints. Dr. Rowe states that "the whole cliff from the fault to Studland Bay is cut in the *B. mucronata* zone, rich in the name fossil and in all the other characteristic fossils associated with it, and at the time of our visit perfectly exposed and accessible in its entire extent." This extent of cliff is about a mile and a third in length and forms the best exposure of the zone to be found in England.

A little way beyond the fault the beds become horizontal for a space and then dip with a gentle inclination to the north.

From Dr. Rowe's measurement it appears that the thickness here exposed is about 250 feet, starting from the plane of the fault, which may be, and probably is, above the base of the zone. He observed a marked layer of large nodular flints at a distance, measured across the beds, of about 100 feet from the cave where the fault reaches the shore, and this flint-layer comes down to the shore 100 yards north of the first Pinnacle. From this point a strong yellow band can be seen at the top of the cliff and "there is roughly 100 feet between the strong flint-line and the strong yellow band. This yellow band can be traced readily to Handfast Point, and Old Harry [a detached pinnacle] shows it well. It is about two-fifths up the cliff at Handfast Point, and gradually sinks as we pass into Studland Bay till it reaches the shore on the west side of the fifth little headland west of Handfast Point. There is about 50 feet of chalk above the yellow band in Studland Bay, so that we obtain a thickness of *Bel. mucronata* chalk of at least 250 feet." The fossils obtained by Dr. Rowe from this zone are included in the list given at the end of this chapter.

Prof. Barrois correctly referred the chalk of Studland Bay to the zone of *Bel. mucronata* and gave measured particulars of the upper 118 feet, in which flints are rather more numerous and occur in layers at distances of from 3 to 8 feet apart. He does not mention the yellow band, but his measurement ends at a bed of "chalk without flints, the surface of which is indurated and corroded." (Recherches, p. 103.)

2.—The Cliffs from Arish Mell to Black Rock.

Passing westward across the Isle of Purbeck we find the Upper Chalk reaching the sea again at Arish Mell, a little cove adjoining Worbarrow Bay and in the cliffs which intervene between this cove and Mupe Bay.

On the eastern side of Arish Mell the chalk is inclined at such high angles that it presents a section from the zone of *Holaster planus* into that of *Actinocamax quadratus*. The zone of *H. planus* at the outer point is not accessible, but that of *Micraster cortestudinarium* can be reached and those of *M. coranguinum* and *Marsupites* are well exposed. The inmost side of the Mell exposes the zone of ***Bel. mucronata***, and the ***A. quadratus*** zone can again be examined in the western cliff; still farther west toward Mupe Bay the lower zones come in again and can be reached along the shore at dead low tide. The following account of each zone has been compiled from the particulars given by Dr. Rowe, and combines what is seen on both sides.

Zone of Holaster planus.—The northern side of Mupe Bay terminates eastward in a little headland known as Black Rock; part of this headland is formed by the zone of *H. planus*, which consists of a greyish nodular chalk without any conspicuous yellow bands. Its thickness is about 50 feet, and it includes a band which is crowded with a small rotiform Bryozoon allied to *Defrancia*.

Zone of Micraster cortestudinarium.—Dr. Rowe describes this zone as consisting of yellow nodular chalk, its colour contrasting with the grey of the *H. planus* zone and the white of the *M. coranguinum* zone, and closely coinciding with the zoological boundaries of the zone. There are frequent but irregular layers of flints, and the total thickness is about 60 feet.

Zone of Micraster coranguinum.—This zone is here about 200 feet thick, and consists of white chalk with regular layers of flints. Fossils appear to be rare, but Dr. Rowe found *M. coranguinum* and its variety, *latior*, with *Galerites albogalerus* and the varieties of *Echinocorys scutatus* which generally occur in this zone. There is no physical or lithological feature to serve as a guide for the top of the zone, and Dr. Rowe's measurement is simply to the point where he obtained the first plate of *Uintacrinus*.

Zone of Marsupites.—Dr. Rowe obtained evidence of the existence of the two sub-divisions of this zone in both the cliff exposures, the *Uintacrinus* band below and the *Marsupites* band above, just as in Kent and Sussex; but the thickness of the zone as measured in the western cliff did not agree with that obtained on the eastern side of Arish Mell. The measurements were:—

	Western side.	*Eastern side.*
Band containing neither *Marsupites* nor *Offaster pillula*	15 feet.	15 feet.
Marsupites-band	12½ "	24 "
Uintacrinus-band.	17 "	30 "
	44½ feet.	69 feet.

As to the explanation of this difference, Dr. Rowe does not think that it is due to a greater amount of compression on the western side, but remarks that the limits of the zone were only fixed by actual collection of the Crinoid plates, and he thinks it possible that they may really be distributed over a greater thickness than he actually proved at his visit. Several other characteristic fossils were found, but no Belemnites occurred.

Zone of Actinocamax quadratus.—The base of this zone was fixed by the first occurrence of *Offaster pillula* and on the eastern side of Arish Mell this was 15 feet above the point where the last plate of Marsupites occurred. But the best exposure of the zone is on the western side, where it occupies the cliffs from Barber's Rock to a point inside Arish Mell, passing round Cockpit Head.

Dr. Rowe remarks that "the southern face of Cockpit Head is, without exception, the best weathered and most fossiliferous that we have worked. . . . The reason is that the cliff is protected by a barrier of fallen blocks of chalk which prevent the face from being pounded by the shingle. The section is not uniformly good, as in parts it is overgrown by seaweed. The chalk is massive, white, free from marly veins and bands, but much slickensided and veined with calcite. . . . Rounding the corner into Arish Mell we find a splendid surface of vertical chalk facing due east. This is all in the *Act. quadratus* zone up to the point indicated in Plate VI." (of Dr. Rowe's paper).

Professor Barrois mentions that there are frequent layers of flints, which are mostly small, pink outside and black inside.

Dr. Rowe's measurement of this zone gave a thickness of 354 feet, the base being fixed by the occurrence of *Act. granulatus* and *Offaster pillula* opposite Barber's Rock, and the summit by the occurrence of *Bel. mucronata* a few feet above that of a fine *Act. quadratus*, *Offaster pillula* being abundant in patches throughout the section. Other fossils, such as *Echinocorys scutatus* var. *gibbus*, *Bourgueticrinus*, *Parasmilia* and Bryozoa are common, and several examples of *Terebratulina Rowei* were found at the base of the zone.

Zone of Belemnitella mucronata.—This zone is only exposed on the western side of Arish Mell, where the cliff becomes low, but the exposure is much obscured by grass-covered talus. It has yielded many examples of *Bel. mucronata*, with specimens of *Magas pumilus*, *Crania costata*, *Kingena lima*, *Terebratula carnea* and other characteristic forms. Dr. Rowe found that 182 feet of this zone come in "from the point of junction with the *Act. quadratus* zone to the sluice," or stream, where the cliff ends. It should also be mentioned that the exposure of this zone in Arish Mell had not been suspected before Dr. Rowe's examination of the coast.

3.—Durdle Cove.

From Arish Mell and Black Rock the narrow outcrop of the uptilted Upper Chalk strikes westward and passes behind Lulworth Cove, St. Oswald's Bay, Man-of-War Cove and Durdle Cove. The zones of *Holaster planus* and of *Micraster cortestudinarium* are exposed in St. Oswald's Bay, but are there very much crushed and compressed. They also come into the cliffs which form the western side of Durdle Cove, where they are traversed by one of the remarkable slide-planes which have been described by Mr. Strahan; this is well illustrated by Fig. 41, which is reproduced from the Memoir on the Geology of the Isle of Purbeck, and also by Plate III. of Dr. Rowe's paper.

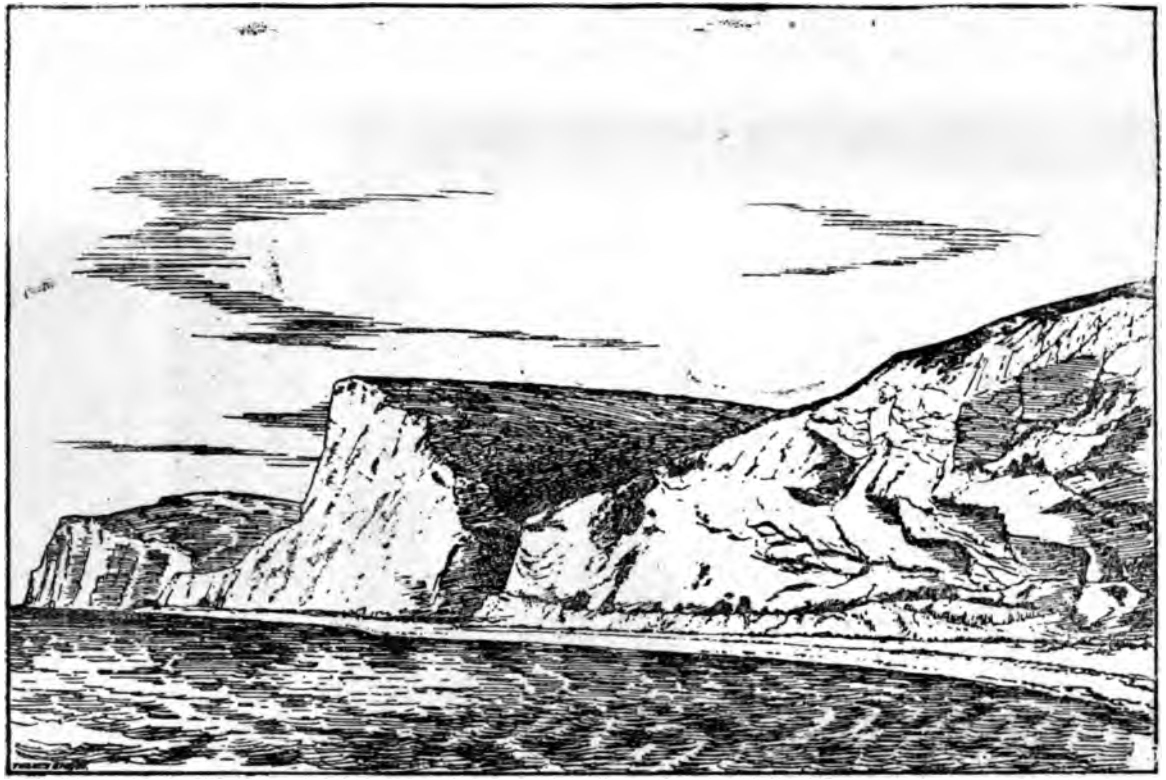
Bats Head.
Swyre Head.
Scratchy Bottom.
Durdle Cove.

FIG. 42.—The Coast from Bats Head to Durdle Cove (from Mr. Strahan's Memoir).

The slide-plane forms a marked feature near the base of the cliff, and Dr. Rowe observes that it traverses two sets of zones. "In its eastern part it has the zone of *Terebratulina gracilis* above and below it; a little further west the zone of *T. gracilis* above and that of *H. planus* below; while in the western and greater part of its extent it has the *H. planus* zone above and the *M. cortestudinarium* zone below, except where the projections at the foot of the cliff jut out farther, where it is again in the *H. planus* zone. . . . ."

"Along the line of weakness caused by the slide-plane the sea has hollowed out a series of little caves (see Fig. 42). The roof in all cases has been pushed northward over the floor of the cave. In the eastern part of the slide-plane the separation has been marked by a sharp line, but in the western part the floor of the cave has been ground up into a paste and cemented together again." (*Op. cit.* p. 16).

Dr. Rowe found that the promontory which forms the western horn of Durdle Cove consists of the grey nodular chalk of the *H. planus* zone and passing round this, "we enter a recess leading by a narrow water-channelled surface to [the combe called] Scratchy Bottom above: . . . . and then follows a good section of inverted *M. cortestudinarium* and *M. coranguinum* zones. The slide-plane is here seen as an oblique line half way up the low cliff at its southern end, intersecting the *M. cortestudinarium* zone." (Rowe, *Op. cit.* p. 16.)

Dr. Rowe found this the best exposure of the zone of *M. cortestudinarium* for fossil-collecting on this coast, but even here it is not so fossiliferous as in Kent or Sussex. He notes however that *Micrasters* are fairly abundant and that the broad *M. cortestudinarium* is here commoner than the oblong *M. præcursor*. Taking the upper limit of the zone at a strong yellow nodular band he gives its thickness as 70 feet; the beds are nearly vertical, but are reversed so as to dip seaward at an angle of about 75°.

This zone is succeeded by that of *M. coranguinum* which occupies the cliff to the head of the recess and is estimated by Dr. Rowe to be 240 feet thick. This thickness may possibly include a little of the zone of *Marsupites*, but he could not find any plates of *Uintacrinus* though he obtained a *Marsupites* plate from a rabbit-hole about 60 paces north of the edge of the cliff.

The cliffs of Swyre Head are in the zone of *M. coranguinum* but their base, being always washed by the sea, is not accessible.

4.—White Nothe to Bats Head.

The cliffs near White Nothe present another good section through the Upper Chalk from its base to the higher part of the *Actinocamax quadratus* zone. The lower zones can be examined both to the west and to the east of White Nothe

Point; on the western side they are high up in the cliff. The Signal-house of the Coastguard Station stands on the zone of *M. coranguinum*, and thence the beds dip down to the shore below West Bottom (*see* Fig. 41, p. 100).

There is a zigzag path leading up from the undercliff to the Signal Station, and west of this are two bluffs which expose faces of the *H. planus* zone, and the path gives a section through the succeeding zones. In 1875, this section was clear enough to be measured, and was examined by Prof. Barrois, whose account is quoted below:—

		Feet.
Zone of *M. coranguinum.*	10. White Chalk with greyish flints in thin discontinuous layers - - - - - - - -	33
	9. Chalk with flints which are pink outside and pale grey within, *Micraster coranguinum*, *Echinoconus conicus*, and many *Cidaris* spines -	66
	8. Chalk with pink-stained flints; many fragments of large *Inocerami* at the base. *Inoc. involutus* -	50
	7. Very hard nodular bed with rolled fossils -	1½
Zone of *M. cortestudinarium.*	6. Chalk with pinkish flints resting on a bed of yellow nodular chalk - - - - - -	4
	5. Chalk with many scattered flints, pink outside, *Salenia granulosa* and many *Cidaris* spines -	13
	4. Chalk with blackish flints in layers, some of which are continuous floors - - - - - -	10
	3. Chalk with black flints, some of them cavernous, and several beds of nodular chalk, one at the base - - - - - - - - - - - -	65
Zone of *H. planus.*	2. Chalk with scattered solid black flints, *Holaster planus*, *Micraster corbovis*, *Cidaris clavigera*, etc.	50
	1. Hard nodular chalk with *Holaster planus* and Micrasters - - - - - - - - -	1½
		293

We have printed the above because Dr. Rowe was unable to measure this section, while Prof. Barrois did not examine the shore section, and consequently no one has yet compared the two. Prof. Barrois thought the highest chalk below the Signal might belong to the zone of *Marsupites*, but Dr. Rowe found the outcrop of this zone, with plates of *Uintacrinus* and *Marsupites* in their proper relative position, in a slipped face at the top of the cliff, 100 yards east of the Signal.

Passing to the shore east of the Signal, a fine line of cliffs is found with a shingle beach below, and this is best reached by boat when the sea is sufficiently smooth for landing. This section is illustrated in Fig. 41, which has been drawn from the six-inch map, and the data given in Dr. Rowe's paper, from which also the following descriptions are taken, with some abridgements.

Zone of Holaster planus.—The base of this zone is taken by Dr. Rowe at the lower of two marl-seams which are 8 feet apart, but he does not state how far this is above the layers of green-coated nodules in the *Terebratulina* zone. He describes the chalk of the *H. planus* zone as grey and marly, with yellow nodular bands which show up strongly. It contains many flints in the upper part, but fewer in the lowest 18 feet. The total thickness is 51 feet, the summit being taken at a layer of large flint nodules which comes to the shore "below a fine upstanding mass of chalk, locally known as the Fountain Rock," though unnamed on the 6-inch Ordnance map.

Zone of Micraster cortestudinarium.—This appears to consist of bands of hard smooth chalk, alternating with beds of hard yellowish and nodular chalk, the latter not being so prominent as usual, and fossils being few and fragmentary. The flints are black with thin white crusts. Dr. Rowe carries the zone up to "a strong ferruginous line of crushed and crowded flint, from 4 to 8 inches thick, which reaches the shore about 100 yards east of Middle Bottom." Between these limits the thickness is 113 feet, which is 21 feet more than the thickness assigned to this zone by Prof. Barrois below White Nothe Signal.

Zone of Micraster coranguinum. — Of this Dr. Rowe writes: "The cliff at this point begins to show much evidence of disturbance. The beds are dipping sharply, and a fine series of slide planes comes into view. We trace this zone from the strong ferruginous flint-band to the first slide-plane, above which is the grass slope on which the seagulls nest. The chalk is firm, and generally white, with regular lines of flints, with black cortices in the lower part, passing into grey in the upper part. Fossils are rare, but *Micraster coranguinum* (type) *Galerites albogalerus* with ovate and dome-shaped varieties of *Echinocorys* were found. For the thickness of the zone he obtained a total of 171, but observes that this is probably an under-estimate. We notice, however, that this figure, combined with that of the underlying zone, makes a total of 284 which is not far from normal.

Zone of Marsupites.—"From the first to the second slide-plane is 81 feet, and from the second to the third is 30 feet. These measurements, curiously enough, coincide with the distribution of *Uintacrinus-* and *Marsupites-* plates . . . The characteristic *Echinocorys vulgaris* var. *pyramidatus* was fairly abundant from bottom to top of the zone . . . The nipple-shaped head of *Bourgueticrinus* was also found. The flints are of a pale grey colour with thick cortices but not zoned." The above measurements give a thickness of 111 feet to the zone here.

Zone of Actinocamax quadratus.—"This zone extends along the shore for over half a mile, and were it not so battered by the shingle would yield many fossils." It is traversed by many slide-planes, and Dr. Rowe used these as fixed points by means of which he obtained the following measurements:—

	Feet.
From 3rd to 4th slide-plane - - - - - -	50
„ 4th „ 5th „ - - - - - -	54
„ 5th „ 6th „ - - - - - -	48
„ 6th „ 7th „ - - - - - -	26
„ 7th „ 8th „ - - - - - -	26
	204

This takes the beds to a layer of flints below the centre of Middle Bottom, where they become almost horizontal for a space of about 100 yards. From this flint-bed to the top of the cliff above is about 50 feet, which gives a total of 254 feet.

"For several hundred yards east of Middle Bottom the cliffs are not much disturbed, but as soon as we reach the point where the beds curve up sharply, slide-planes are common, and we enter a belt of shattered chalk. The chalk on the east side of Middle Bottom must be a repetition of that on the west side, and we here obtained a measurement of 273 feet," which would give a total of 323 feet as exposed. This measurement was taken to a point almost opposite the Calf Rock, where he found the tip of a Belemnite, while a few yards further east a plate of *Marsupites* was found marking the lower limit of the *Act. quadratus* zone. As a result of the measurements, Dr. Rowe expresses the opinion that the zone cannot be less than 350 feet thick, and it will be remembered that at and near Arish Mell the thickness was estimated at 354 feet.

The lower part of the zone, where dipping eastward, consists of firm white chalk with occasional layers of flints. "Eastward of the sixth slide-plane, and up to Middle Bottom, the chalk alters much in appearance, and exhibits a yellowish tinge. . . . The flints were of the same appearance as in the *Marsupites*-zone. The last strong band of *Cardiaster pillula* [*Offaster*] was found at the seventh slide-plane, east of Middle Bottom."

As regards other fossils, Dr. Rowe only found *Actinocamax granulatus* at the base of the zone, but below Middle Bottom he discovered a band of chalk, about 15 feet thick, in which *Act. quadratus* was not uncommon, and he was able to trace this band for nearly a sixth of a mile. *Echinocorys scutatus* var. *gibbus* is abundant throughout, but generally broken by the battering of the shingle.

The highest part of the Upper Chalk is seen in several quarries north of Lulworth, in the country between that place and Wool. In Lulworth Park are two pits near the North Lodge, both of which appear to be in the zone of *Bel. mucronata*, both showing chalk with flints and many small fossils, among which *Magas pumilus* occurs. The eastern pit is close to the Eocene boundary, and is consequently in the highest chalk; it contains some large "Paramoudra" flints like those of the Norwich chalk, and Professor Barrois obtained *Bel. mucronata* here.

Mr. Strahan records chalk with a few flints, containing many *Bel. mucronata*, in a quarry north of Combe Keynes, while to the south of that place, and on a lower horizon, a soft white almost flintless chalk has been dug, which may belong to the *Act. quadratus* zone.

THE COUNTRY ROUND DORCHESTER.

Passing now to the more western part of Dorset, some account may be given of the succession which can be made out from the inland quarries in the neighbourhood of Dorchester.

Chalk Rock and Associated Beds.—Some interesting sections occur in the valley of the Winterborne, south-west of Dorchester, where a special facies of the Chalk Rock is found, and where faults have produced some curious appearances.

The most remarkable section is that of a quarry at the bottom of the road to Dorchester, between Winterborne Abbas and West Steepleton. This section was first described by Professor Barrois in 1876,* who drew attention to the remarkable bed of conglomerate here disclosed, and stated that it included fragments which had been derived from the Upper Greensand. The section as I saw it in 1893 appeared to exhibit the following descending succession:—

		Feet.
White chalk with black flints (not measured).		
Rough nodular chalk with grey flints - - -	about	18
Beds not seen - - - - - - - - - - -	„	10
Hard conglomeratic chalk - - - - - - -	„	4
Massive whitish chalk, full of quartz and glauconite -	„	6
Hard conglomeratic chalk - - - - seen for	„	2

The beds dip at about 50° to N., 15° E., and they look as if they were successive beds in natural order, but the absence of any similar succession elsewhere made me suspect that this appearance was false, and was due to a fault; I thought it possible also that the conglomerate might really be "fault rock." Mr. Strahan subsequently visited the quarry and ascertained that the conglomerate is a single bed, duplicated locally by a fault which strikes obliquely across the outcrop but has no great throw. He is, however, of opinion that the conglomerate is not fault rock but a contemporaneous bed *in situ* and lying above the glauconitic chalk. This conglomerate consists of fragments of hard yellowish chalk like Chalk Rock embedded in a matrix of crystalline granular calcite; here and there also are small rounded inclusions of glauconitic sand which certainly have the appearance of "a greensand," as Professor Barrois states. Moreover, Mr. W. Hill has examined a slice of the rock, and reports that even under the microscope these inclusions have a strong resemblance to certain "Upper Greensand" sandstones. Further, I obtained from it the lower valve of a large *Neithea quadricostata*, which is a form I have never before found in Chalk Rock, but is common in the Greensand. The only other fossils found were *Lima Hoperi*, *Rhynchonella Cuvieri*, and a *Micraster*, all of them small.

It is difficult to reconcile these facts with the view that the conglomerate is Chalk Rock *in situ*, and whether it is or is not

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*Recherches sur le Terr. Crét. Sup., p. 87.

in situ we are of opinion that it contains fragments of sandstone which appear to have been derived from Selbornian strata.

About a mile south-east from this section, and at the opening of a side valley known as Kit Hill Bottom (near Rew Farm), is a quarry which shows the following beds :—

	Feet.
Hard nodular chalk with a few glauconite grains - - -	2
Rough gritty chalk full of quartz and glauconite, and a few flints containing the same minerals - - - - -	1
Very hard nodular chalk, dull and greyish, passing into -	5
Less hard nodular chalk with *Micraster corbovis* - -	5

Here the rough gritty chalk resembles that of the first quarry, but there is nothing like the conglomerate.

Another pit west of the above, and a little lower on the slope, shows at the top hard cream-coloured chalky limestone with massive white chalk below, and still lower rubbly grey and white nodular chalk. The exposure is much weathered and talused, and no fossils were seen.

At Winterborne, St. Martin in a pit south of the Manor House, Chalk Rock of the usual West Dorset facies is seen. It consists of hard, compact, yellowish chalk, weathering into loose angular lumps, and containing the usual fossils; *Holaster planus, Lima Hoperi, Spondylus spinosus, Terebratula carnea,* and *Terebratulina striata* being found in a few minutes.

In this valley, therefore, the Chalk Rock beds seem to present three different facies in as many exposures.

At Park Farm, on the north side of the valley, soft white chalk with flints having a white rind and a milky white band beneath it is seen, and these are characteristic of the *M. coranguinum* zone. Clearly a fault runs along the valley, and at this point brings the *Hol. planus* zone against that of *M. coranguinum.*

At the corner of the road, west of Ashton Farm, is a quarry in hard lumpy chalk with layers of flints which are black inside with very thin rinds. The only fossils obtained were a broad *Micraster* (? *cortestudinarium*) and *Terebratula semiglobosa,* but I have little doubt that it is in the zone of *M. cortestudinarium.*

About a mile from this quarry on the road to Upwey are two quarries, the upper of which shows chalk with rough carious flints, possibly belonging to the zone of *M. coranguinum.* The lower one is in more nodular chalk with similar flints and a course of nodular chalk stained yellow by iron pyrites; below this course I found a *Micraster cortestudinarium.*

The lower beds are then cut off by the Ridgeway fault.

Zone of Micr. coranguinum. The chalk of this zone occupies part of the highest ground to the north and west of Dorchester, and gradually descends to the level of the River Frome. Thus, in the Cerne Valley it occupies the valley-slopes between Godmanstone and Charminster, but there are only small exposures of it. On the north-west it comes down to the river at Stratton and Bradford Peveril. It has already been mentioned that a small exposure of this chalk, containing flints with a milky-white band, occurs at Martinstown, south-west of Dorchester.

The chalk in the quarry mentioned by Professor Barrois near Higher Burton (east of Charminster) may be near the junction of the *M. coranguinum* and *Marsupites* zones. His description of the section is as follows:—

	Feet.
Soft white chalk - - - - - - - - - - - -	3
Layer of flints, which are pink outside.	
Soft chalk with two layers of black flints - - - -	5

From the upper bed above the pink flints he obtained *Offaster pillula, Echinocorys gibbus, Cyphosoma elongatum, Inoceramus* and *Porosphœra globularis.* I should have referred this pit to the *M. coranguinum* zone, but the presence of *Offaster pillula* certainly suggests a higher horizon.

Zone of Marsupites. This zone is probably continuous throughout Dorset, though besides the places near Blandford (see p. 121) I only know of two localities where plates of *Marsupites* have actually been found. One was discovered by my colleague, Mr. Reid, and is near Dewlish, in the cutting on the road to Milborne, which shows chalk with grey flints, overlying soft massive chalk with few flints, and containing plates of *Marsupites.* He also found similar chalk with *Marsupites* in the road to Parsonage Farm. In each case the exposure is on the contour of 300 feet.

The other locality is at Bradford Peveril, north-west of Dorchester, and the pit is on the Dorchester road near the pound, a small exposure showing firm homogeneous chalk with scattered flints, grey or black inside, with a thick white rind, and some of them pink outside. I found two plates of *Marsupites* here.

Zone of Act. quadratus. To this zone I refer most of the chalk with thick-crusted flints, which is exposed here and there to the west of Dorchester.

South of Dorchester and north-west of Herringstone is a quarry in chalk, with a fair number of flints, which have a thick rind and are yellow outside; there is also a band of white marl with lenticular seams of grey marl, but I could not find any fossils.

The cutting on the Great Western line west of Maumbury Ring, Dorchester, may be in this zone, but I could not find any Belemnites, only *Terebratula carnea* and small ovate *Echinocorys.*

Zone of Belemnitella mucronata. The lower part of this zone is exposed in the railway cutting on the Great Western line south of the Bridport road; this is about 30 feet deep, in firm white chalk, with layers of flints at intervals of 4 or 5 feet, and a few scattered nodules. The flints are of very irregular shape, some small and flat, some roundish, others finger-shaped, from 4 to 12 inches in length. All have white rinds of moderate thickness, varying from a quarter to a third of an inch. Here and there the chalk is rough, and full of *Inoceramus* fragments, but most of it splits with a clean smooth fracture. There is no appreciable dip. The fossils found were *Belemnitella mucronata* (several), *Spondylus latus, Echinocorys scutatus,* and *Bourgueticrinus ellipticus.*

West of the railway station and south of Fordington is another cutting in the same zone, but probably in higher beds. Below the level of the rails on the north side blocky chalk with scattered flints of elongate shape and yellow coating has been quarried, and resembles that just described. On the south side a face of some 30 feet is shown above the rails, and this contains very few flints. *Bel. mucronata* occurs in both exposures.

South-east of Dorchester, at Whitcombe, there is a pit in chalk with a few flints, and at West Knighton a pit worked in two levels, showing altogether about 26 feet of chalk, almost destitute of flints, but I did not find any *Belemnitella.* Dr. Barrois, however, found *B. mucronata* in pits at Warmwell and Owermoyne.

North-east of Dorchester chalk with *Bel. mucronata,* and containing a few scattered flints, occurs at Stinsford and Kingston. Professor Barrois found the characteristic fossil also at Piddletown and Burleston. Thus there is sufficient evidence to show that this zone forms a bordering band round the western end of the Eocene area.

FOSSILS FROM THE UPPER CHALK OF SOUTH DORSET.

The following list of fossils from the Upper Chalk of South Dorset has been compiled from the species recorded by Professor Barrois in his "Recherches," by Dr. Rowe in his paper on the Chalk of Dorset, and by Mr. Strahan in his Memoir on the Isle of Purbeck and Weymouth, supplemented with a few found by myself near Dorchester :—

——	Zones of H. planus and M. cortest. 1	Zone of M. corang. 2	Marsupites zone. 3	Zone of A. quadratus. 4	Zone of B. mucronata. 5
Pisces.					
Corax falcatus, *Ag.*	–	–	–	–	5
Lamna appendiculata, *Ag.*	–	–	3	–	5
Oxyrhina Mantelli, *Ag.*	–	–	–	4	–
Ptychodus sp.	–	–	–	–	–
Cephalopoda.					
Actinocamax granulatus, *Blainv.*	–	–	–	4	–
„ quadratus, *Defr.*	–	–	–	4	–
Ammonites leptophyllus, *Sharpe*	–	2	–	–	–

—	Zones of H. planus and M. cortest. 1	Zone of M. corang. 2	Marsupites zone. 3	Zone of A. quadratus. 4	Zone of B. mucronata. 5
Belemnitella lanceolata, *Schloth.*	–	–	–	–	5
„ mucronata, *Schloth.*	–	–	–	–	5
Gasteropoda.					
Aporrhais stenoptera, *Goldf.* (? = Mantelli)	–	–	–	–	5
Dentalium sp. (? planicostatum)	–	–	–	–	5
Pleurotomaria perspectiva, *Mant.*	1	–	–	–	–
Solariella gemmata, *Sow.* (Turbo).	1	–	–	–	–
Lamellibranchiata.					
Inoceramus Brongniarti, *Sow.*	1	–	–	–	–
„ Cuvieri, *Sow.*	1	2	3	4	5
„ involutus, *Sow.*	–	2	–	–	–
„ sp.	1	–	–	–	–
Lima dutempleana, *d'Orb.*	–	–	–	–	5
„ cf. Galliennei, *d'Orb.*	–	–	–	–	5
„ granosa, *Goldf.*	–	–	3	–	–
„ Hoperi, *Sow.*	1	–	–	–	5
Ostrea hippopodium, *Nilss.*	1	2	3	4	5
„ normaniana, *d'Orb.*	1	2	–	–	5
„ semiplana, *Sow.*	1	–	–	–	5
„ vesicularis, *Lam.*	1	2	3	4	5
„ wegmanniana, *d'Orb.*	–	–	–	–	5
Pecten cretosus, *Defr.* (= nitidus, *Mant.*)	–	2	3	4	5
„ (Neithea) quinquecostatus, *Sow.*	1	2	3	–	5
Plicatula Barroisi, *Peron.*	1	–	–	–	–
„ sigillina, *S.P. Woodw.*	1	2	3	4	5
Spondylus dutempleanus, *d'Orb.*	–	2	3	4	5
„ latus, *Sow.*	1	2	3	4	5
„ spinosus, *Sow.*	1	2	3	4	–
Teredo amphisbæna, *Goldf.*	1	–	–	–	–
Brachiopoda.					
Crania egnabergensis, *Retz.*	1	–	–	4	5
„ parisiensis, *Defr.*	1	2	–	–	–
Kingena lima, *Defr.*	–	–	–	–	5
Magas pumilus, *Sow.*	–	–	–	–	5
Rhynchonella Cuvieri, *d'Orb.*	1	–	–	–	–
„ limbata, *Schloth.*	–	–	–	–	5
„ lineolata, *Phil.*	–	–	–	–	5
„ plicatilis, *Sow.*	1	2	3	4	5
„ reedensis, *Eth.*	1	2	3	4	–
Terebratula biplicata ? *Sow.*	1	–	–	–	–
„ carnea, *Sow.*	1	–	3	–	5
„ semiglobosa, *Sow.*	1	2	–	4	–
Terebratulina gracilis, *Schloth.* (var.)	1	–	–	–	–
„ striata, *Wahl.*	1	2	3	4	5
„ Rowei, *Kitchin*	–	–	3	4	–
Thecidium Wetherelli, *Morris*	–	2	3	4	–

—	Zones of H. planus and M. cortest. 1	Zone of M. corang. 2	Marsupites zone. 3	Zone of A. quadratus. 4	Zone of B. mucronata. 5
Bryozoa.					
Entalophora sp.	—	—	—	—	5
Escharina inelegans, *Lonsd.*	1	—	—	—	—
Idmonea cretacea, *Edw.*	—	—	—	—	5
Multinodelea tuberosa, *d'Orb.*	—	—	—	—	5
Spiropora cenomana, *d'Orb.*	—	—	—	—	5
Annelida					
Ditrupa difformis, *Lam.*	—	—	—	—	5
Serpula ampullacea, *Sow.*	1	2	3	4	5
„ **fluctuata,** *Sow.*	1	2	3	4	5
„ **granulata,** *Sow.*	—	—	3	4	5
„ **ilium,** *Sow.*	1	2	3	4	5
„ **lumbricus,** *Defr.*	—	—	—	—	5
„ **macropus,** *Sow.*	—	—	—	—	5
„ **plana,** *Woodw.*	1	2	3	4	5
„ **plexus,** *Sow.*	—	2	—	—	5
„ **turbinella,** *Sow.*	—	2	3	4	5
Echinodermata.					
Bourgueticrinus ellipticus, *Miller*	1	2	3	4	5
Calliderma latum, *Forbes*	—	—	—	—	5
Cardiaster ananchytis, *Leske*	—	—	—	—	5
Cidaris clavigera, *König*	1	2	3	—	—
„ **hirudo,** *Sorig.*	1	2	3	4	5
„ **perornata,** *Forbes*	—	2	—	—	—
„ **pleracantha,** *Ag.*	—	—	—	—	5
„ **sceptrifera,** *Mant.*	1	2	3	—	—
„ **serrata,** *Desor*	—	—	—	—	5
„ **serrifera,** *Forbes*	1	—	—	—	5
„ **subvesiculosa,** *d'Orb.*	1	2	—	—	—
Cyphosoma elongatum, *Cott.*	—	—	—	—	5
„ **corollare,** *Klein*	—	2	—	4	5
„ **Kœnigi,** *Mant.*	—	2	3	—	—
„ **radiatum,** *Sorig.*	1	—	—	—	5
„ **sp.**	—	2	—	—	—
Echinocorys scutatus, *Leske*	1	2	3	4	5
Galerites albogalerus, *Leske.*	1	2	3	—	—
„ **subrotundus,** *Mant.*	1	—	—	—	—
Holaster placenta, *Ag.*	1	—	—	—	—
„ **planus,** *Mant.*	1	—	—	—	—
Marsupites testudinarius, *Schloth.*	—	—	3	—	—
Micraster coranguinum, *Leske*	—	2	3	4	5
„ **corbovis ?** *Forbes*	1	—	—	—	—
„ **cortestudinarium,** *Goldf.*	1	2	—	—	—
„ **Leskei,** *Desm.*	1	—	—	—	—
„ **præcursor,** *Rowe*	1	2	—	—	—
Offaster pillula, *Lam.*	—	2	3	4	—
Oreaster bulbiferus, *Forbes*	—	—	—	—	5

	Zones of H. planus and M. cortest. 1	Zone of M. corang. 2	Marsupites zone. 3	Zone of A. quadratus. 4	Zone of B. mucronata. 5
Oreaster pistilliferus, *Forbes*	1	–	–	–	–
Pentacrinus Agassizi, *Hag.*	1	–	3	–	–
Salenia granulosa, *Forbes*	1	–	–	4	–
Uintacrinus sp.	–	–	3	–	–
Actinozoa.					
Axogaster cretacea, *Lonsd.*	1	2	–	–	5
Caryophyllia cylindracea, *Reuss*	–	–	3	–	–
Cœlosmilia laxa, *E. & H.*	–	–	–	4	5
Parasmilia centralis, *Mant.*	1	–	–	–	5
„ Fittoni, *E. & H.*	–	–	–	4	–
Stephanophyllia Michelini, *Lonsd.*	–	–	–	–	5
Spongida.					
Cliona cretacea, *Portl.*	1	2	3	4	5
Coscinopora infundibuliformis, *Goldf.*	1	2	3	4	5
Doryderma ramosum, *Mant.*	–	–	–	4	–
Guettardia stellata, *Mich.*	1	2	–	4	5
Heterostinia obliqua, *Benett.*	1	2	3	4	–
Leptophragma Murchisoni, *Goldf.*	–	–	–	–	5
Pharetrospongia Strahani, *Sollas*	1	2	3	4	5
Plinthosella compacta, *Hinde*	–	–	–	4	–
Plocoscyphia convoluta, *T. Smith*	1	2	3	4	5
Porosphæra globularis, *Phil.*	1	2	3	4	5
„ pileolus, *Lam.*	1	2	3	4	5
„ Woodwardi, *Carter*	–	2	3	4	5
Siphonia Kœnigi, *Mant.*	1	2	3	4	5
Stichophyma tumidum, *Hinde*	–	2	–	–	–
Ventriculites convolutus, *Hinde*	–	2	–	–	–
„ cribrosus, *Phil.*	1	2	–	–	5
„ decurrens, *T. Smith*	1	2	3	4	5
„ impressus, *T. Smith*	1	–	–	–	–
„ mammillaris, *T. Smith*	1	–	–	–	–
„ radiatus, *Mant.*	1	2	3	4	5

CHAPTER IX.

THE UPPER CHALK IN NORTH AND NORTH-WEST DORSET.

In North Dorset the Upper Chalk forms a broad band, which eventually curves round the western end of the area occupied by the Eocene beds. On the northern side of this area the Chalk dips gently beneath the Eocenes, its broad and unbroken expanse presenting a great contrast to the narrow, disturbed, and faulted tract which has been described in South Dorset.

The Upper Chalk of North Dorset is a continuation of that of Wiltshire, and the same zones can be recognised along the Stour valley between Stourpaine and Wimborne, as have been described near Salisbury.

It is noteworthy that the Upper Chalk of Dorset is thicker than that of Sussex, of Hampshire, and even of the Salisbury district, and this appears to be due not to any increase in the thickness of the lower zones, but to the preservation of a greater portion of the highest zone beneath the Eocene. The following are approximate estimates of the thickness of the several zones, based on the differences of level at which sections in the same zone occur on the borders of the Stour valley :—

		Feet.
Zone of Belemnitella mucronata	about	220
„ „ Actinocamax quadratus - - - -	„	250
„ „ Marsupites testudinarius -	„	150
„ „ Micraster coranguinum - -	„	250
„ „ M. cortestudinarium and Holaster planus	„	80
		950

That these estimates are not excessive is rendered probable by a comparison with the thicknesses given on p. 98 for South Dorset, and on p. 71 for South Wilts.

1. Zones of Holaster planus and Micraster cortestudinarium.

The Chalk Rock is shown in several quarries on the hills between Melbury and Stourpaine, its outcrop at the former place being 730 feet above the sea, while near the latter it passes below the alluvium of the Stour.

One of the best sections is in a quarry E.N.E. of Sutton Waldron, where about 7 feet of the rock are exposed without reaching its base. It consists of very hard nodules or lumps of compact limestone, embedded somewhat loosely in a softer matrix, the whole forming a nodular mass without division into layers; a few pieces of light brown phosphate occur, but no green-coated nodules, and fossils are not abundant. At the top is a continuous seam of black flint overlain by rough nodular chalk with flints. The total thickness of the rock-beds appears to be about 12 feet, and judging from a section near East Compton, the lowest bed of the rock is about two feet thick, having a layer of green-coated nodules at the top, and passing down into less hard nodular chalk.

In the railway cutting south of Stourpaine a somewhat different set of beds is exposed, and the thickness is greater, thus:—

		Feet.
Chalk Rock Beds.	Loose nodular chalk with shaly layers and a layer of shaly chalk at the base - - - - - - -	10
	Hard rough nodular rock - - - - -	3
	Hard compact cream-coloured rock with a layer of green-coated nodules at top - - - - - -	2
	Blocky greyish-white chalk, rising to the north and exposed for about - - - - - - -	20
		35

The overlying beds are exposed in a quarry just north of the bridge over the railway; they consist of hard and rough nodular chalk, greyish-white, with grey streaks and seams, and enclosing many scattered flints, which are solid and grey inside, with a white rind, which blends into the flint. This chalk seems to be well bedded, but crumbles into a rough irregular face; it probably belongs to the zone of *Micraster cortestudinarium,* but the only fossil seen was *Echinocorys scutatus.* Some of the nodular lumps were brownish inside, as if slightly phosphatic.

Similar chalk is exposed in the next cutting on the railway to the southward, and here I found a good specimen of *M. cortestudinarium.* In the next cutting near Nutford the chalk is white and compact, containing large irregular flints of the cavernous or "carious" type; some are grey inside, some brown, and others have a tinge of red, and many are full of sponge spicules.

Beds which probably occupy a place intermediate between those in the two cuttings last mentioned are exposed in a pit by Whitecliff Mill, which is about 20 feet deep in whitish chalk rough and lumpy, with numerous flints, some small and imperfectly silicified, others large and knobby, many of which are cavernous and spiculiferous. Fragments of a large and thick *Inoceramus* are common, but no other fossils were seen.

West of the valley of the Stour the outcrop of the Chalk Rock has been traced by my colleague, Mr. Reid, along the escarpment of Okeford Hill, and thence southward to Bulbarrow and Hilton Down. It also crops out on the inner side of this ridge, and surrounds the irregular inliers of Middle and Lower Chalk by Turnworth, Houghton Winterborne, Hilton, and Milton Abbas. An old quarry at Clenston Farm (Winterborne valley) shows about 20 feet of rough-bedded greyish-white rubbly chalk, with layers of solid black flints. I found *Micraster cortestudinarium* here, and the chalk doubtless belongs to the zone characterised by that species.

The country between Hilton and Cerne has been mapped by Mr. Reid, who found no difficulty in tracing the Chalk Rock by surface indications, but remarks that there are few good exposures of it. It is in this district that a hard and compact chalky limestone first shows itself in the beds above the Chalk Rock, and there appear to be sometimes two beds of this. Thus, at the south end of Piddletrenthide, above the school, Mr. Reid saw the following section in a chalk-pit:—*

	Feet.
Soft chalk with grey flints (thick rinds) - - - - -	2
Hard nodular crystalline chalk with casts of sponge spicules -	2
Rubbly chalk with black flints having thick rinds - -	12

A few feet higher another bed of very hard splintery limestone occurs, and forms a marked ledge across the road.

In the Cerne valley the Chalk Rock first appears at Nether Cerne, where it is exposed in a small quarry east of the village. About 6 feet of hard nodular rock with yellowish stains, and a few scattered green-coated nodules pass down into softer chalk. I found here *Echinocorys scutatus*, *Holaster planus*, *Terebratula semiglobosa*, *Terebratulina gracilis* (var.), *Inoceramus* sp., *Guettardia stellata*, *Ventriculites impressus*, and *V. alcyonoides*?

Near Oakham Close, in a combe on the west side of the valley, pathways cut in the steep slopes of the hills show the following succession:—

	Feet.
White chalk with occasional layers of solid black flints- about	20
White chalk without flints - - - - - - - „	12
Grey glauconitic chalk with *Holaster planus*, *Terebratula semiglobosa* and *Rhynchonella reedensis* - - - -	2
Hard nodular chalk-rock with a bed of very hard compact limestone at the base - - - - - - - -	10 or 11

On Dickley Hill, west of Cerne, the same Chalk Rock, weathering into angular lumps, crops out in the roadway at about 590 feet. Higher up is, first, hard lumpy chalk, then chalk with solid flints, and at 630 feet a bed of very hard compact rock, with a splintery fracture, crosses the road and forms a step in the gutter.

Exactly the same succession is exposed on Eastfield Hill, east of Sydling, but here there does not seem to be more than 30 feet of chalk between them The upper rock appears to be about 2 feet thick.

The same two hard beds have been noticed on the eastern side of the Frome valley, near Cattistock, and are exposed in the roadway up the hill south of Langcombe Bottom, south-east of Maiden Newton.

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*Geology of Dorchester, Mem. Geol. Survey, 1899, p. 12.

Near Cruxton, on the opposite side of the Frome, a roadway leading up to Hill Barn traverses the whole of the Middle Chalk. The lower part of this section has been given in Vol. ii. p. 427, and above the beds which are there described as forming the zone of *Terebratulina* the following ascending succession can be made out, the thicknesses being approximate only:—

		Feet.
1	Compact Chalk-Rock, weathering yellow - - - -	1½
2	Hard nodular Chalk with scattered flints in the upper two feet - - - - - - - - - - - - -	6
3	Bed of yellow chalk-rock, weathering brownish - - -	1
4	Very hard whitish chalk-rock, with glauconite, breaking into sharp angular lumps - - - - - - - - - -	?4
5	Whitish sandy (or shelly) chalk, soft but enclosing hard lumps and flints; *Terebratula carnea*, *Rhynch. octoplicata*, *Micraster* and a broken *Holaster* - - - - - -	?4
6	Rough nodular chalk without flints.	

Above this the cutting is so shallow that no measurements could be taken, but there is some thickness of the nodular chalk without flints, and above it comes hard white massive chalk, and then a layer of hard compact yellowish rock, very like the upper Chalk Rock below; but it is not the same bed repeated by a fault, for the chalk above is hard, white, and nodular. After some 10 or 12 feet of this the uppermost compact white limestone crops out, like that between Cerne and Sydling, with the same splintery fracture. Here it seems to be about 35 feet above the lower Chalk Rock, but as the section is throughout a shallow one, it is possible that the lower beds of Chalk Rock have slipped a little from their real position.

Hard nodular buff-coloured chalk with *Micraster cortestudinarium* is exposed in a quarry south-west of Southover Farm, and is capped by a layer of tabular or continuous flint 9 inches thick.

The Chalk Rock crops out again at Notton; and further south in an old pit between Notton and Throop the following section is seen in what is probably part of the *M. cortestudinarium* zone:—

	Ft.	*in.*
Bedded white chalk with flints - - - - - - -	5	0
Very hard nodular rock, yellowish, with casts of sponge spicules, passing into lumpy chalk with flints - -	2	3
Soft grey marly chalk - - - from 6 inches to	0	9
White compact chalk, passing down into nodular chalk -	2	0
Hard chalk full of yellow coated nodules, passing down into bedded chalk with layers of flints - - - -	6	0

In the large outlying tract which lies between the upper valley of the Frome and the head waters of the Axe, the Chalk Rock has only been seen in one place. This is in an old quarry, by the 700 feet contour line, on the western side of the main road, north of Toller Whelme, and near Hill Barn. The exposure open in 1895 was small, but showed the following beds:—

	Feet.
Traces of compact rock below the soil, in one place soft mealy chalk enclosing lumps of hard chalk and large solid flints, *Holaster planus*, *Rhynchonella reedensis*, *Cyphosoma sp.*	2
Hard lumpy chalk full of green-coated nodules - - -	½
Hard compact crystalline limestone, becoming lumpy in the lower part, no green nodules. *Terebratula carnea*, *Rhynchonella octoplicata*, *Septifer lineatus*, and *Ostrea normaniana* - - - - - - - - -	2 or 3
Soft white mealy chalk below.	

The outcrop of the "Rock" could probably be traced for a mile or two to the eastward, but westward it is soon overlapped by the Clay-with-flints, and is probably cut off by a fault, which runs up the Toller valley.

2. Zone of Micraster coranguinum.

This zone probably occupies a considerable tract of country along and east of the ridge of the main escarpment, for it is exposed in several chalk pits within a little distance of the main road from Blandford to Shaftesbury, as, for instance, in a pit 1½ miles east of Iwerne Minster, where the characteristic flints can be seen, *i.e.*, black flints with a band of milky white colour, at a little distance from the external surface.

This zone comes down to the level of the river and the railway at Blandford. The lowest part of it is shown in the cuttings near Whitecliff Mill, the chalk containing many scattered flints of irregular shapes, black inside, with a very thin rind, and a layer of cavernous flints tinged with red. Further south in the cutting north of Blandford Station, firm white chalk, containing layers of flints with an internal white band. *Micraster coranguinum* is fairly common here,

Still further south, in the cutting west of St. Mary's Church, there are flints without any rind, but black and solid throughout, but at the southern end a band of flints with white rinds comes in, and further south the flints have thick rinds, as usual at the top of the M. *coranguinum* zone.

These upper beds with thick rind flints can be seen in chalk-pits on the higher ground both to the east and west of Blandford, as, for instance, in the Norton pit, about two miles west of that town, which is 20 feet deep in chalk, with numerous scattered flints of this kind, but fossils are scarce.

A small pit near Normandy Farm, two miles W.S.W. of Bryanston, is interesting as again showing the chalk containing flints with milky-white bands, many of them with spongiferous hollows, and some stained pink or reddish. The chalk is rather tough, with some beds of more shelly chalk of a yellowish tint, which are full of fragments of *Inoceramus*-shell. I found a few fossils here—*Micraster coranguinum, Ostrea lateralis, Rhynchonella* sp., and a fish tooth.

Zone of Marsupites.

In this part of Dorset the *Marsupites* chalk is by no means a flintless chalk. It contains, on the contrary, an abundance of flints—scattered, and seldom in regular layers—having very thick white rinds, so that many of the smaller nodules seem to be nearly all white rind or crust. They are always solid, never cavernous.

Chalk with such flints is exposed in the cuttings on the railway south of Littleton and west of Charlton Marshall, but a prolonged search in them only resulted in the discovery of one *Marsupites* plate. *Marsupites* are, however, common in the Thorncombe pit about two miles west of Charlton; the chalk in this quarry is of very even grain, brittle when dry, and splitting easily in straight planes in any direction. Flints are abundant as scattered nodules, but not in continuous layers, though a few may lie in line for a few yards; they have very thick white rinds and are yellowish outside.

Another quarry about a mile from this, and nearly a mile south-west of Down House, shows exactly the same kind of chalk, and plates of *Marsupites* are equally abundant, with small *Echinocorys scutatus* and stems of *Bourgueticrinus*. The difference of level between the two pits is about 200 feet, and there is no appreciable dip at either place. The general inclination is probably toward the south-east, but even allowing for this, the thickness of the zone would not seem to be less than 150 feet, unless a fault intervenes; the *Uintacrinus* band has not been discovered.

Still further to the south-west, on Whatcombe Down, half a mile west of Charisworth House, is another quarry 12 to 14 feet deep in exactly the same chalk, from which I obtained *Marsupites*-plates *Bourgueticrinus ellipticus, Kingena lima,* and a small thin-shelled *Ostrea.*

The chalk of this zone evidently occupies a considerable surface area between the valleys of the Stour and the Winterborne south of Blandford Down House.

Zone of Actinocamax quadratus.

Along the line of railway the chalk of this zone is first seen in the cutting by the northern end of Spettisbury (south of St. John's church). This is about 30 feet deep in homogeneous white chalk, splitting evenly in any direction; flints occur in layers at distances of 2 to 4 feet apart, but are not, on the whole, more numerous than in the zone below; they have a thick white crust, which generally includes a band of chalcedonic flint. A short search for fossils yielded *Actinocamax granulatus, Echinocorys scutatus, Spondylus latus, Sp. dutempleanus ?* and *Kingena lima.*

Near Spettisbury station is a chalk pit about 15 feet deep at a lower level, but in the same chalk.

In the cutting at the south end of Spettisbury, opposite Crauford House, there is similar chalk, from which I obtained several broken Belemnites which appeared to belong to *Bel. lanceolata*, a species which is associated with *Act. quadratus* near Salisbury.

On Whatcombe Down this zone comes in near Charisworth House, about 30 feet higher than the pit where Marsupites occur, for Mr. C. Reid informs me that he found *Offaster pillula* in a small pit 150 yards south-west of the house.

On the eastern side of the Stour the zone of *Act. quadratus* might be expected to occur in the Tarrant valley, but so far as I could judge by a passing visit, the chalk there resembled that of the upper part of the *M. coranguinum* zone, and I found no traces either of Marsupites or of Belemnites.

There is a pit at Tarrant Crauford, east of Abbey Farm, showing chalk with an irregular fracture and flints with a rind of moderate thickness; the upper 15 feet contains scattered flints only, the lower 10 feet has three layers of flints, as well as scattered nodules. The fossils found were *Echinocorys scutatus*, *Terebratula carnea ? Rhynchonella* (young), and *Porosphæra globularis*.

At Tarrant Kingston is a pit in similar chalk, but the flints have thicker rinds. No fossils were seen.

Zone of Belemnitella Mucronata.

Along the line of rail this zone is first seen in a chalk pit by the bridge over the railway near Moorcourt Farm. The chalk is much decomposed and broken, flints are not numerous, but are black inside, without any rind, and resemble those of Shootend, near Salisbury. *Terebratula carnea*, *Echinocorys scutatus*, and *Bel. mucronata* were the only fossils found.

There are better exposures on the other side of the river near Shapwick and Sturminster. A quarry east of Shapwick, on the road to New Barn Farm, shows about 20 feet of soft white chalk with a few scattered yellow-coated flints. Small ovate *Echinocorys* are common here, and I also found several *Belemnitella mucronata*, a *Salenia granulosa*, some small *Ostrea* and *Porosphæra globularis*.

East of Sturminster Marshall, and close to the bridge over the river, is a large quarry showing about 16 feet of soft white chalk without any flints, though unworn flints with thick rinds occur in the soil at the top. The dip is very slight, apparently to the east. *Belemnitella mucronata* is not uncommon, and I found also *Kingena lima*. The level of the floor of this quarry is 81 feet above O.D., and the hill known as Badbury Rings to the N.N.E. rises to over 300 feet, hence there would appear to be at least 200 feet of chalk belonging to the zone of *Bel. mucronata* in this district.

Professor Barrois found the higher beds of this zone exposed in a quarry at Highwood, and describes the chalk as very soft and divided into beds about two feet thick by marly seams stained yellow by iron ; the flints are few, and have a thick rind. He also notes exposures at Broadford barrow and at Ashford, north of Wimborne.

The chalk of this zone must occupy a broad tract of country outside the boundary of the Eocene area between Wimborne and Piddletown, near Dorchester. There is a small exposure in its lower beds to the north of Almer on the northern side of Great Almer Wood, the flints being few and small, but fossils more abundant.

It is seen again in a large pit south of Winterborne Kingston, which shows about 25 feet of soft white chalk with a few scattered yellow-coated flints, and one layer of flints about four feet from the base. This chalk is traversed by oblique and slightly curved planes of division, which cut up the mass into long lenticular layers, but are not planes of bedding. The flint layer shows a slight dip to the south-west. *Belemnitella mucronata* was the only fossil seen.

No careful zonal collecting of fossils from the Upper Chalk of northern Dorset has yet been accomplished. The late Mr. Shipp, of Blandford, collected largely from that neighbourhood, and I have availed myself of a printed catalogue of his collection in which many fossils are indicated as coming from Thorncombe (*Marsupites* zone). This collection is now in the Dorchester Museum. For the other zones, the species recorded in the following list were mostly collected by myself during my traverses of the county, and a few by Mr. C. Reid.

FOSSILS FROM THE UPPER CHALK OF NORTH AND WEST DORSET.

———	The two lowest zones.	Zone of Micr. coranguinum.	Zone of Marsupites.	Zone of Act. quadratus.	Zone of Bel. mucronata.
Pisces.					
Ptychodus polygyrus, *Ag.*	–	–	x	–	–
Mollusca.					
Actinocamax granulatus, *Blainv.*	–	–	x ?	x	–
Belemnitella mucronata, *Schloth.*	–	–	–	–	x
,, lanceolata, *Schloth.*	–	–	–	x	–
Inoceramus involutus, *Sow.*	–	x	–	–	–
,, sp.	x	–	–	–	–
Lima Hoperi, *Sow.*	–	x	x	–	–
Ostrea semiplana ? *Sow.*	–	–	x	–	x
,, canaliculata, *Sow.*	–	x	–	–	–
,, normaniana, *d'Orb.*	x	–	–	–	–
,, vesicularis, *Lam.*	–	–	x	–	–
,, sp. (small)	–	x	–	–	–
Pecten mantellianus, *d'Orb.*	–	–	–	–	x
,, (Neithea) quinquecostatus, *Sow.*	–	–	x	–	–
Septifer lineatus, *Goldf.*	x	–	–	–	–
Spondylus dutempleanus, *d'Orb.*	–	–	–	x	–
,, latus, *Sow.*	–	–	–	x	–
,, spinosus, *Sow.*	x	x	x	–	–

	The two lower zones.	Zone of Micr. coranguinum.	Zone of Marsupites.	Zone of Act. quadratus.	Zone of Bel. mucronata.
Brachiopoda.					
Kingena lima, *Defr.*	–	–	x	x	x
Rhynchonella limbata, *Schloth.*	–	–	–	–	x
„ octoplicata, *Sow.*	x	x	x	–	x
„ reedensis, *Eth.*	x	–	–	–	–
Terebratula carnea, *Sow.*	x	x	x	–	x
„ semiglobosa, *Sow.*	x	–	–	–	–
Terebratulina striata, *Wahl.*	–	–	x	–	–
„ gracilis, *Schloth.*	x	–	–	–	–
Echinodermata.					
Bourgueticrinus ellipticus, *Miller*	–	x	x	–	–
Cidaris sceptrifera, *Mant.*	–	x	x	–	–
Cyphosoma Kœnigi, *Mant.*	–	–	x	–	–
„ sp.	x	–	–	–	–
Echinocorys scutatus, *Leske*	x	x	x	x	x
Epiaster gibbus, *Lam.*	–	x	–	–	–
Galerites albogalerus, *Leske*	–	x	x	–	–
Holaster planus, *Mant.*	x	–	–	–	–
Marsupites testudinarius, *Schloth.*	–	–	x	–	–
Micraster coranguinum, *Leske*	–	x	x	–	–
„ cortestudinarium, *Goldf.*	x	–	–	–	–
„ Leskei, *Desm.*	x	–	–	–	–
„ præcursor, *Rowe*	x	–	–	x	–
Offaster pillula, *Lam.*	–	–	x ?	x	–
Oreaster obtusus, *Forbes*	–	–	x	–	–
Salenia granulosa, *Forbes*	–	–	–	–	x
Actinozoa.					
Parasmilia centralis, *Mant.*	–	x	x	–	–
Spongida.					
Guettardia stellata, *Mich.*	x	–	–	–	–
Porosphæra globularis, *Phil.*	–	–	x	–	x
Ventriculites alcyonoides ? *T. Smith*	x	–	–	–	–
„ impressus, *T. Smith*	x	x	–	–	–
„ sp.	–	–	–	–	–

CHAPTER X.

THE UPPER CHALK IN SOMERSET AND DEVON.

GENERAL DESCRIPTION.

In these counties there are only a few small outliers of Upper Chalk, and these consist only of the lowest part of this division: the zones of *Holaster planus* and *Micraster cortestudinarium*. Two of these outliers are in Somerset, north of Chard, and the others are on the coast of Devon, one small tract lying between Lyme Regis and Rousdon, and two others at Beer, separated only by the valley in which that village lies.

The coast sections are much more complete than those of the inland quarries which do not reach above the Chalk Rock.

The zone of *Holaster planus* near Lyme is fairly well marked, setting in with a band of hard splintery rocky chalk which resembles the Chalk Rock of North Dorset and contains small fragments of brown phosphate of lime. It is overlain by lumpy and nodular chalk, and in the Pinhay cliffs this zone appears to be about 40 feet thick, but is reduced to 24 feet at Beer, where the rocky bed at the base is not more than 2 feet thick. Both near Lyme and at Beer a conspicuous layer of large flints forms a convenient plane of division between this and the overlying zones.

The zone of *M. cortestudinarium* also consists for the most part of rough lumpy chalk with one or more layers of hard yellowish rocky chalk. *Micraster præcursor* with varieties approaching *M. cortestudinarium* occurs in some abundance, and some 50 feet of this chalk can be measured. In the lower part the flints are solid and mostly black inside, but higher up there are some cavernous flints.

That the zones of *M. coranguinum* and *Marsupites testudinarius* originally extended over Devonshire is proved both by the flints and the flint fossils which are found in the gravels capping the higher plateaux. These include casts of *Micraster coranguinum*, of *Galerites albogalerus*, and of *Marsupites*-plates, and the flints are of three sorts, some cavernous with branching cavities enclosing remains of *Doryderma ramosum*; some solid and translucent with a milky white band near the periphery, and thirdly flints which are solid and light grey throughout.

by Dr. A. W. Rowe, from whose account the following is condensed.[*] At the foot of the main cliff west of the Chapel Rock and just above the talus he noticed a thin layer of marl, below which *Ter. gracilis* var. *lata* is abundant, associated with *Micraster corbovis* and some *Holaster planus*; above the marl *H. planus* becomes commoner and is associated with *M. Leskei* and *M. præcursor*, consequently the marl seam coincides with the zoological change from the zone of *Terebratulina* to that of *Hol. planus*. At 26½ feet above the marl-seam he found a "strong" layer of flints and 13 feet higher a thin continuous seam of flint ("tabular band"). He found the fauna of the *H. planus* zone extending up to this flint-seam, but above it the Micrasters change, "*Micraster corbovis, M. Leskei* and *Holaster planus* die out and are replaced by *Micraster præcursor* of the group-form associated with the zone of *M. cortestudinarium*. This thin tabular flint-band is therefore the dividing line between the zones of *Holaster planus* and *Micraster cortestudinarium*."

Continuing upwards Dr. Rowe noticed two seams of marl, one 4 feet and the other 8 feet above the flint-seam ; higher up are two bands of yellow nodular chalk and near the top a stronger band of hard yellow nodular rock. He did not measure these beds but estimates their total thickness at from 45 to 50 feet, referring all this to the zone of *M. cortestudinarium*, while that of *Hol. planus* has a thickness of nearly 40 feet.

The hard yellow rock is also seen at the top of Chapel Rock, the southern face of which presents a fine weathered section of the two zones ; on it the same guiding features can be traced, the lower 30 feet belonging to the zone of *Hol. planus*, and at the base of the mass 16 feet below the strong bed of flints are two other noticeable flint-layers. Dr. Rowe describes the chalk of the *Hol. planus* zone as consisting mainly of hard iron-stained nodular beds with not a few phosphatic and glauconitic nodules scattered throughout; he found two examples of *Solariella gemmata* and one of *Pleurotomaria perspectiva*, but he will not admit that any of it can be called Chalk Rock. If the term "Chalk Rock" is restricted to a special lithological type then we agree with him. but the hard fragments in the zone of *H. planus* at Pinhay have the characteristic structure of Chalk Rock under the microscope (see p. 303) ; they only differ from the typical aspect of the rock in not forming continuous beds of hard limestone with layers of green-coated nodules.

The Chalk of Pinhay cliff dips to the eastward, so that the zone of *Hol. planus* rises westward and is not seen in the great cleft at the western end of the cliff, though it must only just escape coming into it, as shown in Plate II. of Dr. Rowe's paper.

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[*] See Proc. Geol. Assoc., Vol. xviii., Part I. (1903), being the third part of Dr. Rowe's Memoir on the "White Chalk of the English Coast."

In Whitlands cliff I could not find any trace of the *Hol. planus* zone, and if present it must be only just in the centre of the cliff below the gravel capping; nor is it again seen at any point between this and the month of the Axe.

The next outlier of Upper Chalk is that which is truncated by the cliff on the northern side of Beer Harbour. The upper part of this cliff is known by the name of Annis' Knob and the footpath from Beer to Seaton runs by it. (See Fig. 43.)* Although this bluff is not much over 50 feet high both the zones of *Micraster cortestudinarium* and of *Holaster planus* appear to come in, the latter being thinner than near Lyme. About the middle of the bluff is a conspicuous course of large black flints, and as *Hol. planus* is abundant below this flint band and was not found above it, I took it as a convenient line of separation between the two zones. My note of the succession here seen in 1894 is as follows :—

		Feet.
Zone of *M. cortestudinarium*, 29 feet.	Chalk with many layers of flints, some of them with hollow spaces; some hard nodular lumps in lower part, *Micraster cortestudinarium*, *Terebratula carnea*, *Porosphæra globularis*, and *Inoceramus* - - - - - - - - - -	10
	Hard rough nodular chalk with a yellowish rocky bed at the top containing fragments of brownish phosphate. Many flints, the whole weathering in rough layers. *Micraster* common - - -	10
	Hard rough nodular chalk with flints and a band of very hard yellowish rock at the top. *Echinocorys scutatus*, *Micraster*, *Rhynchonella reedensis*, and a coral (? *Parasmilia*) - - - - - -	7½
	Soft greyish-white chalk without flints - -	1
	Conspicuous layer of black flints - - - -	½
Zone of *Hol. planus*, 23 feet.	Rough chalk with many scattered flints, and hard nodular lumps arranged in layers, *Holaster planus*, *Micraster Leskei*, *M. cortestudinarium*, *Terebratula carnea*, and *Rhynchonella reedensis* -	12
	Hard rough chalk with many scattered flints and some small bits of light brown phosphate, *Holaster planus*, *Rhynchonella plicatilis*, *Terebratulina gracilis*, *var. lata* ? *Terebratula carnea*, and *Cyphosoma radiatum* - - - - - -	10
	Rough chalk full of very hard yellowish lumps and some light brown phosphates - - seen for	1

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* A front view of this bluff has been given in Vol. II. of this Memoir, p. 439.

On the east side of the bluff above the path there is a small fault with a downthrow to the east bringing in about 20 feet of the higher and less nodular chalk with cavernous flints.*

The Upper Chalk is exposed again in the old quarries north-west of Beer (see vol. II. p. 446), where about 30 feet of hard nodular chalk come in above the bed which I take as the base of the zone of *Holaster planus.*

The last outlier of Upper Chalk is that of Beer Head, and this is only accessible in two places. A conspicuous band of flints, which is probably that above mentioned, can be seen near the top of the cliff at the headland above Little Beach, and the beds of the *M. cortestudinarium* zone can be reached from the cliff-top north of the headland, at a place where a slice has slipped down and left an exposed face. The section shows rough nodular chalk with some yellowish rocky beds, and from them Mr. Rhodes obtained some of the characteristic fossils, *Micraster præcursor* and *M. cortestudinarium* being fairly common. The other place is in the bluffs adjoining and above the path which leads down from the top of the cliff east of the Coastguard Station. Mr. J. Rhodes collected from these bluffs in 1894, and supplied me with the following note of the beds.

		Feet
B.	Rough chalk with scattered flints and a layer of flints at the base, not accessible - - - - -	8
	Rough chalk with scattered flints and a conspicuous layer of flints at the base - - - - - - - -	24
A.	Rough chalk with hard lumps and a few flints, *Holaster planus* found near top and also at base - - - -	16
	Rough yellowish nodular chalk with scattered bits of brown phosphate. *Micraster corbovis*, *Hol. planus*, *Cyphosoma radiatum* and *Pleurotomaria sp.* - -	2

From the characters of the two lower beds I judge them to belong to the zone of *H. planus*, of which there is probably more below.†

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* Dr. Rowe has since collected from these beds, and states that the actual zoological passage from the zone of *H. planus* to that above occurs about 10 feet above the marked layer of flints; if this is so, and if the lowest bed seen is not more than 2 feet thick, the thickness of the *H. planus* zone is here, in my opinion, about 34 feet. Dr. Rowe, however, places its base some 26 feet lower than I do, on the assumption that a certain marl-band, seen in the cliff but not accessible, is the same as that which divides the zones at Pinhay. I have referred the beds above this marl-band at Beer to the *Terebratulina* zone.

† Dr. Rowe was unable to identify the zone of *H. planus* at this spot, and as he gives no description of the beds he did see above the path it is impossible to tell whether the exposure he mentions was the same as that above noted.

The zone of *Holaster planus* rises westward from Beer Head, and finally crops out at the top of Hooken cliffs near the Coastguard Station.

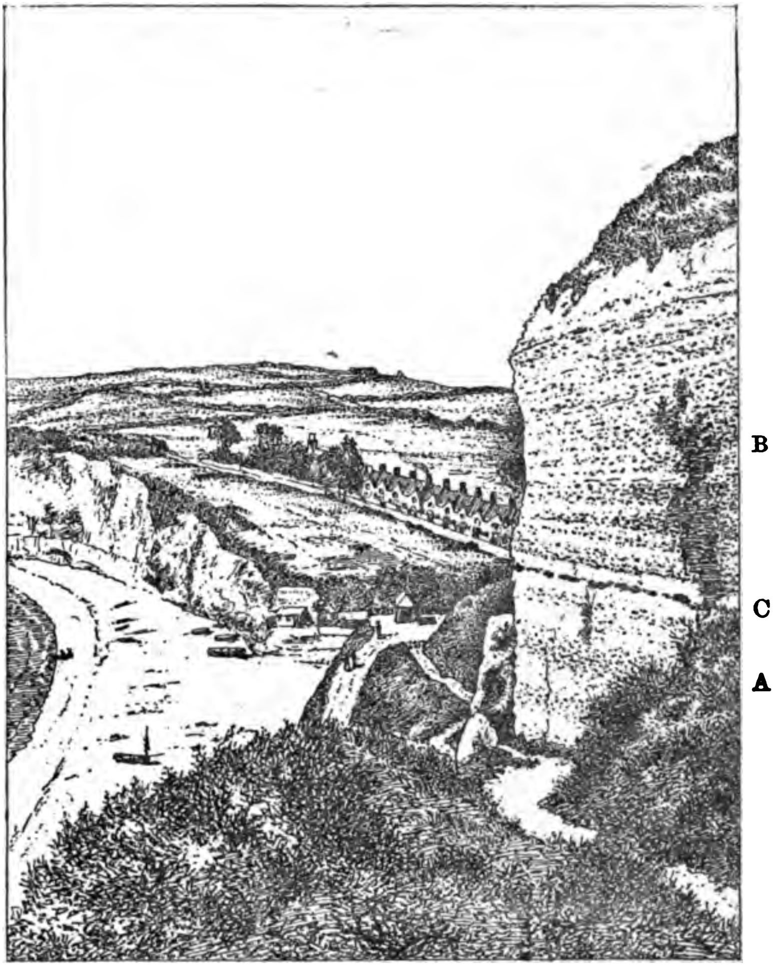

Fig 43.—View of Annis Knob, South of Beer, showing the zones of *Holaster planus* (A) and *Micraster cortestudinarium* (B); the conspicuous layer of flints (C). From a photograph by Mr. E. Good of Seaton.

The Flint Gravel of the Haldon Hills.

As stated on p. 125, evidence for the previous existence of still higher zones in Devonshire is furnished by the fossils found in the flints which form extensive tracts of gravel not only on the patches of Chalk near the coast, but also on the ridges and plateaux of Selbornian sands which stretch thence to the northward.

The most westerly tract of such gravel is that which caps the Haldon Hills, south-west of Exeter. These gravels are in places as much as 20 feet deep, and are believed to be of Eocene age. The flints they contain are mostly of a very pale whitish-grey colour inside and many fossils have been obtained from them, collections of these being preserved in the Museums at Exeter and Torquay. The most interesting of these are plates of *Marsupites testudinarius*, the occurrence of which was recently recorded by me in a short note from which the following remarks are quoted:—

"The [plates are] casts in pale grey flint, and it is somewhat remarkable that they show a strongly-marked arrangement of ridges corresponding with those on the more ornate varieties of *M. testudinarius*. As the inner surface of all plates of *Marsupites* is smooth, I conclude that the plates embedded in flint were partially silicified, but even then it is not easy to understand the persistence of the ornament unless this is structual and not merely an external ribbing. . . .

"So far as I can ascertain, no remains of Belemnites have been found in the Haldon flints. Prof. Clayden has kindly made enquiries for me at Exeter, and has searched through the collection in the Albert Museum, but has not found any trace of Belemnites or of fossils characteristic of the zones of *Actinocamax quadratus* or *Belemnitella mucronata*. . . . . It should, however, be remembered that even if no fossils belonging to higher zones than that of *Marsupites* should ever be found on Haldon, their absence will not mean more than the absence of such zones within the area at the time when the Bagshot Beds were formed. It will not prove that the higher zones never extended into Devonshire, but simply that they were destroyed during the upheaval of the Chalk and before the formation of the Bagshot Beds.

"The occurrence of the plates of *Marsupites* does, however, enable us to form an estimate of the total thickness of Chalk which may have existed in the neighbourhood of what are now the Haldon Hill when the Bagshot gravels were being accumulated. The Lower Chalk would be represented by only a few feet of calcareous sandstone, as on the Devon coast, and may consequently be neglected; the Middle Chalk is about 100 feet thick at Beer, and the mean thickness of the zone of *Holaster planus* in Devon is about 40 feet. To get an estimate of the thickness of the zones of *Micraster cortestudinarium* and *M. coranguinum* we must go to Dorset, where the mean of several measurements gives 80 feet for the former and 200 feet for the latter. Finally, the thickness of the zone of *Marsupites* was found to be 111 feet near White Nothe, and *Marsupites* are only found in the upper 30 feet; if this thickness was maintained to the westward, the total thickness of Chalk under erosion in Devonshire would be as follows:—

	Feet.
Zone of *Marsupites testudinarius* - - - - -	111
„ *Micraster coranguinum* - - - - -	200
„ *Micr. cortestudinarium* - - - - -	80
„ *Holaster planus* - - - - - -	40
Middle Chalk - - - - - - - - -	100

"We may therefore safely assume that the Haldon gravels represent the riddlings of about 500 feet of Chalk.

"The following is a list of the fossils obtained from the flints in the gravel on the summit of the Haldon Hills, and preserved in the Museums of Exeter and Torquay. For a list of those at Exeter I am indebted to the Curator, Mr. F. R. Rowley; these are indicated by the letter E, and those at Torquay by T.

Inoceramus Brongniarti ? *Sow.* E, T.
„ mytiloides, *Sow.* E, T.
„ sp. (large and flattish.) T.
Lima Hoperi, *Sow.* E, T.
Pecten cretosus, *Defr.* E.
Septifer lineatus, *Sow.* T.
Spondylus spinosus, *Sow.* E, T.
Rhynchonella Cuvieri, *d'Orb.* E, T.
„ limbata ? *Schloth.* E.
„ reedensis ? *Eth.* E.
„ plicatilis, *Sow.* E, T.
„ „ var. octoplicata, *Sow.* E, T.
Terebratula carnea, *Sow.* E, T.
Cidaris clavigera, *König* (spines). E, T.
„ hirudo, *Sorig.* (spine) T.
„ sceptrifera, *Mant.* (tests.) E, T.
„ perornata, *Forbes* (spine). E, T.
Cyphosoma Kœnigi, *Mant.* E, T.
Echinocorys scutatus, *Leske.* E, T.
Galerites castanea, *Brongn.* T.
„ albogalerus, *Leske.* E, T.
Marsupites testudinarius, *Schloth.* E, T.
Metopaster Mantelli, *Forbes.* E.
Micraster coranguinum, *Leske.* E, T.
„ præcursor ? *Rowe.* T.
„ cortestudinarium, *Goldf.* T.
Ophiura serrata, *Roem.* (cast of disc and arm.) E.
Cliona cretacea, *Portl.* E, T.
Doryderma ramosum, *Mant.* E.

"This assemblage is probably derived mainly from the zone of *Marsupites* and *M. coranguinum*, but includes specimens from the zones of *M. cortestudinarium* and *Hol. planus* and possibly from the *Terebratulina* zone."

FOSSILS FROM THE UPPER CHALK OF THE COAST.

The following list of fossils includes those found by Mr. Rhodes and by myself, and also incorporates a list kindly sent me by Dr. A. W. Rowe of the fossils obtained from these zones by himself

and Mr. Sherborn in 1898. The letter *c* indicates that the species is common, *f c*=fairly common, and *r*=rare.—

—	Zone of H. planus.	Zone of M. cortest.
Ptychodus mammillaris, *Ag.*	–	r
Nautilus cf. atlas, *Whit.*	–	r
Pleurotomaria perspectiva, *Mant.*	r	–
Solariella gemmata, *Sow.* (cast)	r	–
Inoceramus Cuvieri, *Sow.*	f c	–
„ Brongniarti ? *Sow.*	r	–
„ sp.	r	–
Ostrea semiplana, *Sow.*	–	r
„ vesicularis, *Lam.*	–	r
Plicatula Barroisi, *Peron*	r	r
Spondylus spinosus, *Sow.*	f c	c
Crania egnabergensis, *Retz.*	r	–
Rhynchonella Cuvieri, *d'Orb.*	f c	r
„ plicatilis, *Sow.* (large)	r	r
„ reedensis, *Eth.*	r	r
Terebratula carnea, *Sow.*	c	f c
„ semiglobosa, *Sow.*	f c	f c
Terebratulina gracilis, *Schloth.* (var.)	r	–
„ striata, *Wahl.*	r	f c
Desmepora semicylindrica, *Roem.*	–	r
Eschara Acis, *d'Orb.*	r	–
Fasciculipora cretacea, *d'Orb.*	–	r
Homœosolen ramulosus, *Lonsd.*	–	r
Melicertites (Clausa) globulosa, *d'Orb.*	–	r
Serpula ilium, *Sow.*	f c	f c
„ plexus, *Sow.*	–	r
Bourgueticrinus ellipticus, *Miller*	c	c
Cardiaster pygmæus, *Forbes* (large)	–	r
Cidaris clavigera, *König*	r	f c
„ sceptrifera, *Mant.*	–	r
„ serrifera, *Forbes*	f c	c
„ hirudo, *Sorig.*	f c	–
Cyphosoma radiatum, *Sorig.*	f c	r
Echinocorys scutatus, var. gibbus, *Lam.*	f c	f c
Goniaster (ossicles)	c	c
Holaster planus, *Mant.*	c	–
„ placenta, *Ag.*	f c	f c
Micraster corbovis, *Forbes*	f c	–
„ cortestudinarium, *Goldf.*	r	c
„ Leskei, *Desm.*	c	–
„ præcursor, *Rowe*	c	c
Pentacrinus sp.	r	–
Salenia granulosa, *Forbes*	r	–
Parasmilia centralis, *Mant.*	–	r
Guettardia stellata, *Mich.*	r	–
Plocoscyphia convoluta, *T. Smith*	c	f c
Porosphæra globularis, *Phil.*	c	r
Ventriculites decurrens, *T. Smith*	r	–
„ impressus, *T. Smith*	c	r

CHAPTER XI.

THE UPPER CHALK OF THE KENTISH COAST.

NOTICE OF PREVIOUS STUDIES.

The earliest description of the Upper Chalk as exposed in the cliffs of Kent is that by William Phillips in 1818[*], republished in Conybeare and Phillips' "Geology of England and Wales," but this description only included the cliffs between Dover and Deal, not those of the Isle of Thanet.

The structure of the Isle of Thanet was first explained by Mr. W. Whitaker in 1865;[†] when he showed that the beds are raised into a low anticline (or perhaps the half of a dome or pericline, the eastern part of which has been worn away by the sea). He also pointed out that "the comparatively flintless chalk of Margate is above the more flinty chalk of Broadstairs," and that the latter forms the upper part of what Phillips had called "the chalk with many flints."

In 1870 Mr. G. Dowker wrote a paper "On the Chalk of Kent,"[‡] with a section showing the sub-divisions of the Kentish Chalk, as based on lithological differences; the Upper Chalk of Kent being divided into three parts—(1) Margate Chalk, (2) Ramsgate Chalk, and (3) St. Margaret's Chalk, the second including Whitaker's "Broadstairs Chalk," and all the "chalk with many flints," while the third comprised all the rough nodular chalk seen in the cliff at St. Margaret's, near Dover.

Mr. Whitaker's "Geology of the London Basin"[‖] embodies the information obtained by Phillips and himself with respect to the coast section, adding some fresh particulars.

The Chalk of the Isle of Thanet was the subject of a careful examination by Mr. F. A. Bedwell in 1873,[§] who specially studied the zone in which large *Ammonites* occur in the cliffs, giving a detailed diagram of the cliff section, a tabular measurement of the beds exposed, and important particulars of the continuity of certain layers of flint.

The next contribution to our knowledge was from Professor E. Hébert,[¶] who described the whole of the chalk in the cliffs between Folkestone and St. Margaret's, grouping the beds in zones according to the classification which he had adopted for the French Chalk, and finding a close correspondence between the zones on each side of the English Channel.

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[*] Trans. Geol. Soc., Vol. v. p. 16.

[†] Quart. Journ. Geol. Soc., Vol. xxi. p. 395 (1865).

[‡] Read before the Geol.Assoc. and published in Geol. Mag., Vol. vii. p. 466.

[‖] Mem. Geol. Survey, Vol. iv. 1872.

[§] See Geol. Mag., Dec. 2, Vol. i. p. 16 (1874).

[¶] Bull. Soc. Géol. France, Ser. 3, T. ii. p. 416 (1874).

This description was supplemented in 1876 by the publication of Dr. Ch. Barrois' "Recherches,"* in which he added further particulars of the chalk at Walmer, Broadstairs, and Margate, and assigned the beds to four zones, namely :—

1. Zone of *Marsupites*=Margate Chalk
2. Zone of *Micraster coranguinum*=Chalk of Broadstairs and Walmer.
3. Zone of *Micr. cortestudinarium* } Chalk of St Margarets.
4. Zone of *Holaster planus* }

At that time he included the zone of *M. cortestudinarium* in the *Senonian* stage, and referred the zone of *Hol. planus* to the Turonian, but, as already explained, we shall include both in our Upper Chalk.

Mr. W. Hill described the chalk which forms the zones of *Hol. planus* and *M. cortestudinarium* in 1886†, and compared these beds near Dover with the Chalk Rock beds of Oxfordshire and Buckinghamshire.

Quite recently the whole of the coast section from Dover to Margate has been carefully studied and searched for fossils by Dr. A. W. Rowe, of Margate, his results being published in March, 1900.‡ This memoir differs from its predecessors in being little occupied with lithological details, and in being essentially a study of the zonal divisions. The author adopts the zones established by Hébert and Barrois, and by more exhaustive collecting of the fossils he has determined the exact junctions of the several zones, or rather he indicates the beds within which one zonal fauna changes to another, and certain horizons which can be taken as bases for measurement of thickness. This paper, with its long and well identified list of fossils, showing their zonal distribution, is a valuable contribution to our knowledge.

Mr. W. Hill also paid several visits to the coast near Dover during 1897, 1898, and 1899, and on the last occasion he had the advantage of comparing notes with Dr. Rowe. The result is that we are able to make our description agree very closely with that published by Dr. Rowe, and at the same time to supplement it by more continuous particulars of the beds comprised in the lower zones.

Fig. 44 shows the positions occupied by the lower zones of the Upper Chalk in the cliffs near Dover.

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* Recherches sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irelande. Mem. Soc. Géol. du Nord. 4to. Lille.

† Quart. Journ. Geol. Soc., Vol. xlii., p. 239.

‡ The Zones of the White Chalk of the English Coast: Part I., Kent and Sussex; Proc. Geol. Assoc., Vol. xvi. p. 289.

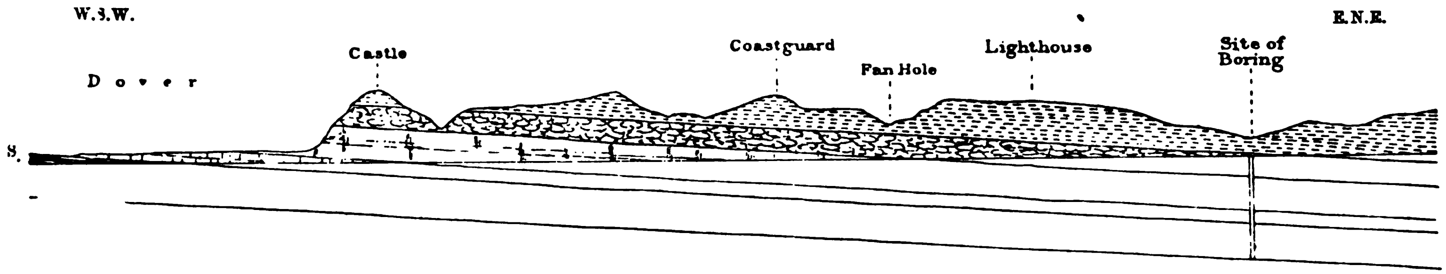

FIG. 44.—Section along the coast east of Dover.

Horizontal Scale, 1½ inch to a mile. Vertical Scale, 900 feet to an inch.

C^2 Zone of Micraster coranguinum.
C^1 Zones of M. Cortestudinarium and H. planus.
B^2 Zone of Terebratulina.
B^1 Zone of Rhync. Cuvieri.
A. Lower Chalk.
SS. Sea level.

STRATIGRAPHICAL DETAILS.

Zone of Holaster planus.

As already mentioned in the second volume of this Memoir, p. 372, what we take to be the base of this zone is a bed of chalk about four feet thick, full of flints, which at the top and bottom tend to become arranged in line, so as to form two layers. In this bed *Holaster planus* is fairly common. We take this bed as the base of our zone of *Holaster planus*, partly because that fossil is more abundant in and above it than it is below, but mainly because a bed in which flints are thickly scattered occurs at about the same horizon in the inland exposures along the North Downs, and serves as a guide in dividing this zone from that of *Terebratulina*. This flinty bed is not everywhere equally well developed, and may not be constant, but the marl band, which occurs 13 feet lower at Dover, is not persistent inland, and it is therefore much more convenient to take the former as the base of the *Hol. planus* zone.

Based upon this flinty chalk, the following succession of beds can be seen in the cliff at Fan Hole, east of Dover :—

	Ft.	*in.*
7. Rough chalk consisting of hard lumps in a softer matrix, some scattered flints and many fossils	2	6
Layer of flints	0	4
6. Smooth firm white chalk.	1	4
A thin seam of marl		
5. Smooth firm white chalk.	1	4
Layer of flints	0	4
4. Rough lumpy chalk with *Hol. planus*	2	0
3. Seam of soft marl, forming a marked plane	0	2
2. Rough lumpy chalk with *Hol. planus*	3	6
1. Two layers of flints forming top and base of lumpy chalk with many scattered flints	4	0
	15	6

It will be noticed that the beds between the two upper layers of flints present a curiously symmetrical arrangement ; this has been noticed by most observers, and is recorded both by Phillips and Hébert, and is shown in Fig. 45. Dr. Rowe takes the base of the zone at the central open seam of marl (3), but for reasons above given we prefer to take it at 7½ feet lower.

The succeeding beds can be examined along the course of the path which is known as Langdon Stairs.

The rough chalk at the top of the section just given is the lowest part of a band of similar chalk which is about 17 feet thick. It consists of lumps or nodules of hard creamy yellow chalk arranged irregularly, not in layers, but close together, so that they form the bulk of the mass ; while the interspaces are filled with a soft marly kind of chalk. Flints are scattered throughout. Micrasters especially *M. Leskei* (= *breviporus*) and *M. præcursor*, are very

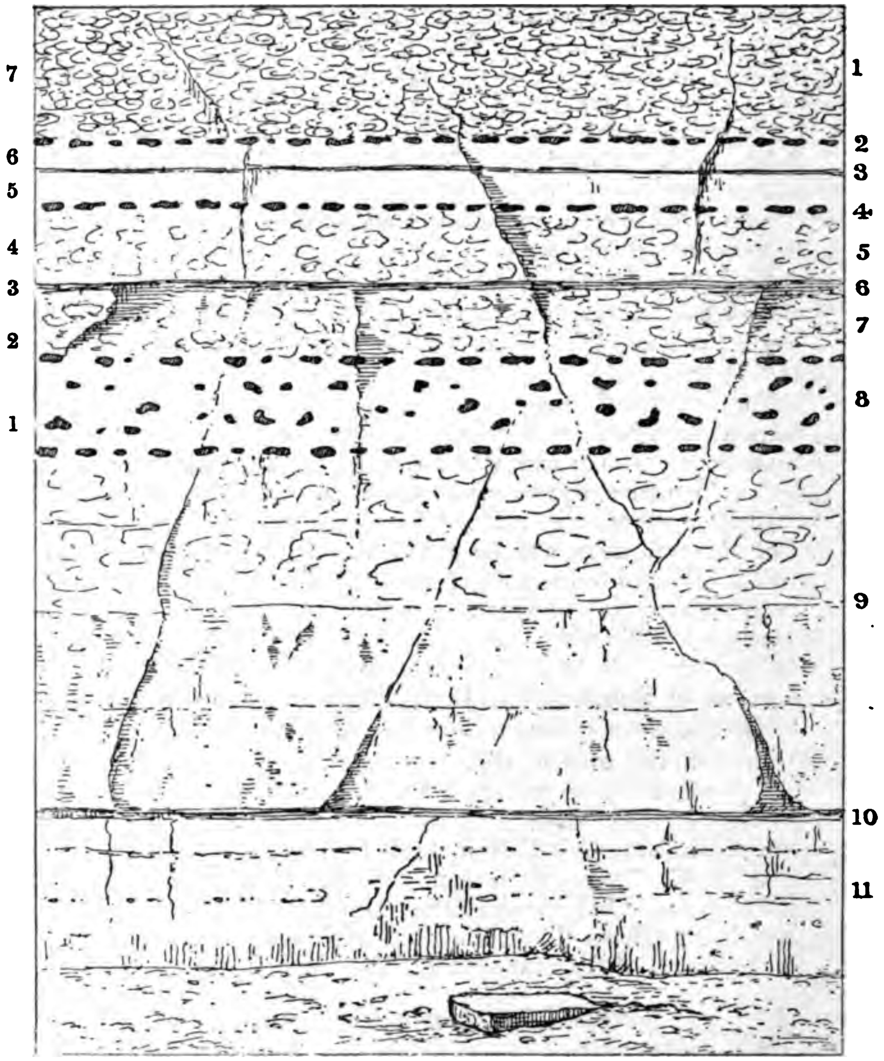

FIG. 45.—View of a portion of the cliff east of Dover, showing the beds at the junction of the *Terebratulina* zone with that of *Holaster planus.* The numbers on the left side refer to the description given on p. 138.

abundant in this chalk; *Holaster planus* and *Echinocorys scutatus* are not uncommon, and Gasteropods of Chalk-rock species make their appearance in it.

Above this is a well-defined bed consisting of lumps of hard, compact, cream-coloured chalk about a foot thick with a clearly marked upper surface. This is succeeded by whiter and less nodular, but still somewhat lumpy, chalk, in two courses, which are together 4½ feet thick. Then comes a bed of hard, yellowish, nodular chalk, which weathers into knotty projections, and is about 2 feet thick, followed by 6 feet of hard, yellowish, rocky chalk, rather rough and lumpy, but more solid than the beds below. Scattered flints occur in each of these beds, and show a tendency to arrangement in layers.

We believe that the plane which we take as the top of the *Hol. planus* zone is the same as that taken by Dr. Rowe, but as we begin the zone 7½ feet lower than he does we get a total thickness of 43½ feet.

The beds above described can be easily identified in the detailed section published by Hébert in 1874; they correspond to his numbers 15 to 20 inclusive, to which he gives a combined thickness of 14·75 metres, equivalent to about 48 feet. The greater part of this, however, was referred by him to the upper part of his *Inoc. labiatus* zone, and he was doubtful whether even the beds 18–20 belonged to the zone of *Holaster planus*. This latter zone he considered to be represented mainly by about 26 feet of the overlying chalk which we assign to the zone of *Micraster cortestudinarium*. It is evident that he was guided more by the presence of Holasters than by the Micrasters, but the fact serves to show how closely the two zones are related.

Part of the zone of *Hol. planus* comes into the top of the cliffs west of Dover and in 1901 Dr. Rowe was able to obtain its characteristic fossils from the debris of a great fall from the top of Shakespeare's Cliff in 1899.* The chalk contrasts with that of the *Terebratulina* zone in being of a greyish tint and full of flints. Judging from the characters of the Micrasters he found, Dr. Rowe thinks that this cliff includes the lower and central parts of the zone, but not the highest part.

Zone of Micraster cortestudinarium.

The whole of this zone can also be examined by continuing the ascent of Langdon Stairs.

Above the rocky chalk last mentioned there is softer chalk with a few scattered flints for 7 or 8 feet, this bringing us to an angle of the zigzag path; above this comes similar chalk terminating in a bed of hard yellowish nodular rock, the whole about 6 feet thick and overlain by a continuous seam of flint.

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* Proc. Geol. Assoc., Vol. xvii., p. 190 (1901).

Above this continuous or tabular layer of flint the beds become whiter, and, on the whole, softer and less nodular, but there still occur at intervals beds of hard rough lumpy chalk, such courses being generally from 12 to 18 inches thick. This kind of chalk continues for a thickness of about 60 feet, and contains many scattered flints, with a few (three or four) well-marked layers of flints.

There is no very definite top to the zone, that is to say, there is no bed of marked lithological character at or near the passage from this zone to the next which might be regarded as its summit. We have simply taken the highest of the markedly rough and lumpy beds of chalk as the top of the zone. This is at a height of 75 feet above the summit of the *Hol. planus* zone, and 8½ feet below the seam of flint which Dr. Rowe calls the "*coranguinum* tabular."

This thickness does not agree with the measurements taken by Dr. Rowe in St. Margaret's Bay, where this zone comes down to the shore. At that place (Canterbury Hole), he found the summit of the zone of *M. cortestudinarium*, coinciding with the highest yellowish nodular bed, to be 15 feet below the "*coranguinum* tabular," and 26 feet above the "*cortestudinarium* tabular;" from which latter to the base of the zone only 30 feet intervened, thus making a total thickness of only 56 feet.

If both his and our measurements are correct, it would appear that the zone has increased in thickness by 19 feet in passing from the one point to the other, a distance of about two miles. If, however, the zoological summit of the zone at Langdon Stairs should prove to be at the same distance below the *coranguinum* tabular as at Canterbury Hole, then the increase of thickness would be only 12½ feet.

Viewed as a whole the zone of *M. cortestudinarium* may be described as consisting mainly of chalk which is greyish in colour with marly patches and veins, but at intervals occur bands of hard, nodular, yellowish chalk, which weather out in rough relief. "This chalk," says Dr. Rowe, "is very curious, as we have hard yellow nodular bands, from which fossils can hardly be extracted, and soft patches from which they can be removed with a pocket knife. The soft marly pockets are rich in Bryozoa and Foraminifera."

The flints of this zone are more or less scattered, and even where they tend to run into a layer, they are generally placed irregularly in a certain thickness of chalk. Many of them are cavernous, and sponge-remains are common.

The prevalent fossils are Micrasters with deeply-subdivided or strongly inflated ambulacral groves, *Holaster placenta,* and *Echinocorys scutatus,* var. *gibbus.*

The following measurements of the beds composing the zones of *Holaster planus* and *M. cortestudinarium* at Langdon Stairs were taken by Mr. Hill in 1898 :—

		Ft.	*in.*
Zone of *Micr. coranguinum.*	Firm white chalk with layers of flints, about	30	0
	White chalk with scattered flints (to corner of 1st slope)	12	0
	White chalk with scattered flints	8	0
	Thin layer of tabular flint (the "*coranguinum* tabular")	0	2
	Course of rather rough lumpy chalk without flints	3	0
	Chalk with some flints at top and bottom	1	6
	Chalk with few flints	4	0
Zone of *Micraster cortestudinarium*, about 75 feet.	Chalk with hard lumps and no flints	3	6
	White chalk, somewhat lumpy, with scattered flints, to bottom of second slope	9	6
	White chalk in four beds, two without flints and two with scattered flints	11	6
	Weak layer of tabular flint	0	1
	Chalk with scattered flints passing down into lumpy chalk	3	9
	Firm white chalk with scattered flints and a fairly marked layer at the top	7	9
	Rather rough lumpy chalk with flints	2	0
	White chalk, rather lumpy but without flints	3	3
	White chalk with scattered flints	2	0
	Well marked bed of hard creamy lumps	1	0
	Less lumpy chalk with scattered flints	1	9
	Hard rough yellowish lumpy chalk with flints	3	0
	Passing down to softer white chalk with a well marked layer of flints at base	3	6
	Smooth firm white chalk without flints	2	0
	Hard rough lumpy chalk	1	0
	Layer of flints	0	6
	Chalk of irregular lumpy texture with some scattered flints in the middle	4	6
	Thin layer of tabular flint	0	1
	Rough chalk with yellowish limestone lumps, passing into smoother chalk to bottom of 4th slope	6	0
	Lumpy chalk with a few scattered flints	3	0
	Rough lumpy yellowish chalk with some flints	3	0
	Whiter and less lumpy chalk	2	9
Zone of *Holaster planus*, 43 feet 6 inches.	More compact yellowish chalk passing down into lumpy chalk	6	0
	Two beds of hard yellowish chalk with 4½ft. of whitish lumpy chalk between them	7	6
	Rough lumpy chalk, more or less hidden by talus	17	0
	Smooth chalk between two layers of flints	3	4
	Rough lumpy chalk	2	0
	Seam of marl (Dr. Rowe's base)	0	2
	Rough lumpy chalk	3	6
	Chalk with many flints (see p. 138)	4	0

It will be noticed that in this section there are two thin continuous layers of flint, and that neither of them corresponds exactly in position with that which Dr. Rowe has called "the *cortestudinarium* tabular." Dr. Rowe took the lower layer to be this horizon, and says that he checked the measurements with those taken further east, but we doubt if they agree as closely as he supposed.

If the above section be compared with that given by Professor Hébert it will be seen that it includes the beds which he numbered 21 to 26, and probably also 27, which he describes as terminating in "a bed of hard chalk 1 metre thick." The thickness of beds 21 to 27 inclusive he makes about 73 feet.

Dr. Rowe does not give a tabular view of the succession in St. Margaret's Bay, but he mentions certain lithogical details and gives measurements between certain horizons, from which the following may be inferred as his view of the succession :—

		Feet.
	Strong tabular layer of flint	–
	Chalk with flints (*M. coranguinum* zone)	15
Zone of *M. cortest.* 56 feet.	Chalk with several well-marked yellow nodular bands from 7 to 5 feet apart	26
	Thin layer of tabular flint	–
	Chalk with yellow nodular bands	15
	Marked layer of flint-nodules	–
	Chalk [? whiter and less nodular]	15
	Marked layer of flint-nodules	–
Zone of *H. planus*, 34½ feet.	Nodular chalk (no description given)	16
	"Chalk Rock," a series of nodular beds containing brown phosphate nodules	9
	Nodular chalk	4
	Chalk with two layers of flints	5½
	Open seam of marl	–

Dr. Rowe terms a certain thickness of beds in the *Hol. planus* zone "the Chalk Rock," and appears to have been under the impression that they had been previously so called, which is a mistake. We do not regard these particular beds as the exact equivalent of the Chalk Rock of the Midland Counties, though they may represent part of it.

Zone of Micraster coranguinum.

This is the chalk which William Phillips described as "chalk with many flints and with few organic remains," a brief description which is quite correct. The beds of flints are frequent, occurring at distances of from 18 to 36 inches, and being on the average less than two feet apart. Fossils are not abundant, and are absolutely rare in the lower part. On this point we may quote Dr. Rowe's remarks in his recent paper on the Kentish coast section,* "Fossils are uniformly distributed through the upper three-fourths of this zone, being perhaps a trifle more abundant at the top than elsewhere; but the base is nearly always singularly barren in organic remains"

The cliff at the north end of St. Margarets Bay consists entirely of this chalk, but it is not very easy to measure, and Hébert's section is the only detailed account yet published (Op. cit. p. 425). Of this the following is a translation in descending order:—

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*Proc. Geol. Assoc., Vol. xvi. p. 303.

	Feet.
Chalk with flints - - - - - - - about	50
Thick continuous band of flint.	
Soft white chalk with flints in regular layers - - -	98
Chalk with numerous layers of flints and many fragments of *Inoceramus*. *Micraster coranguinum* found -	40 to 50
Dry homogeneous chalk without flints - - - -	3
Soft white chalk with many flints and many scattered fragments of *Inoceramus*. Found *Inoceramus involutus* and a *Micraster* - - - - - - - - - - -	10
Soft chalk with scattered flints, a thick bed of flints at the top and an argillaceous layer near the base. *M. coranguinum ?* and *Holaster placenta* - - - - -	11½
Chalk with two thin continuous layers of flint - - -	1
Soft white chalk with some flints - - - - -	6½
About	230

In all probability the "thick band of flint," about 50 feet from the top in this section, is the bed first described by Mr. Bedwell in 1874 as the "columnar band."* This, he says, is like a mass of "irregular honeycomb," and it is a foot or more thick, "but its chief peculiarity is this, that from it at irregular intervals spring perpendicularly columns of flint, similar in constitution to itself, and extending to a height of a foot or a foot and a half." This bed he himself identified in Walmer cliffs, and its importance lies in the two facts, first of its persistence and second of its serving as a guide line to a layer of tabular flint which comes in about 30 feet above it both in the Walmer cliffs and in those of the Isle of Thanet.

This second marked layer of flint is known as the "three-inch band," a name given to it by Mr. Bedwell in the paper above mentioned; the existence of this layer was, however, first pointed out by Mr. Whitaker,† who also indicated its occurrence near the top of the Walmer cliffs, an observation confirmed by Mr. Bedwell, and more recently by Dr. Rowe. The importance of this bed is that it is known to be just 21 feet below the base of the *Marsupites* zone.

Dr. Rowe does not give any particulars or measurement of the zone as seen in the cliffs between Dover and Kingsdown, except saying that these two flint bands can be traced all along the upper part of the cliff, and that the higher one (the 3 inch band) rises to the top of the cliff at St. Margarets Bay. Appended to the paper, however, is a section drawn to scale by Mr. C. D. Sherborn, and the thickness shown in this between the lines drawn for the base of the zone and the "3-inch band" is about 230 feet. Adding 21 feet to this, we have a thickness of about 250 feet for that of the whole zone. We believe this to be correct, and that there was some little error in Hébert's measurements near the base of the zone.

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* Geol. Mag., Dec. 2, Vol. i. p. 19 (1874).

† Mem. Geol. Survey, Vol. iv. p. 31 (1872).

The succession may probably be summarised as follows :—

	Feet.
Soft chalk with flints	21
Three-inch tabular band of flint	–
Soft chalk with flints	30
Strong tabular flint (Columnar Bed)	–
Soft chalk with layers of flints	100
Soft chalk with layers of flints and many fragments of *Inoceramus* shell	60
Soft chalk with scattered flints	20
Strong layer of tabular flint	–
Soft white chalk with scattered flints	15
	246

Near Kingsdown the cliff passes into a grass-covered slope, and the chalk is concealed from view. There are, however, several pits a little way inland, and one S.W. of the Deal Waterworks is worth notice because we have definite information for which we are indebted to Dr. Rowe who visited it in 1901. He writes, "The chalk is massive, with regular layers of black compact flints; we found *Micraster coranguinum* and the var. *latior*, *Echinoconus conicus*, *Cidaris sceptrifera C. peromata*, *C. clavigera*, the large dome-shaped *Echinocorys*, and *Actinocamax verus*, but no trace of *Uintacrinus*. I have no hesitation therefore in referring this chalk to the zone of *M. coranguinum*."

Pegwell Bay coincides with a syncline occupied by Eocene Beds, but the Chalk rises again on the north side of the bay, and is exposed in the fine cliffs which border the eastern part of the Isle of Thanet.

In Thanet the beds are bent into a broad and flattish anticline, as shown in Fig. 46, consisting of the upper part of the *M. coranguinum* zone (Ramsgate and Broadstairs chalk), overlain by the *Marsupites* zone (Margate chalk). Mr. Whitaker has observed that although the chalk of the *M. coranguinum* zone occupies a large part of the cliff-section, it cannot take up much of the surface area inland, for the base of the Margate chalk is nowhere far above the summit level of the cliffs, and the land generally rises inland from the cliff-edge; consequently the flinty chalk will only crop out along the bottoms of some of the valleys (see Mem. Geol. Survey, Vol. IV., p. 35).

The following brief account of the cliff section is based upon the descriptions given by Mr. Bedwell, Professor Barrois, and Dr. Rowe.

The zone of *M. coranguinum*, with here and there a capping of the "Margate Chalk," forms the cliffs all the way from Ramsgate to Kingsgate. The "three-inch layer" of flint is brought up into the cliff south of Ramsgate by a fault (see Fig. 46). A little further on it runs out to the top of the cliff, but comes

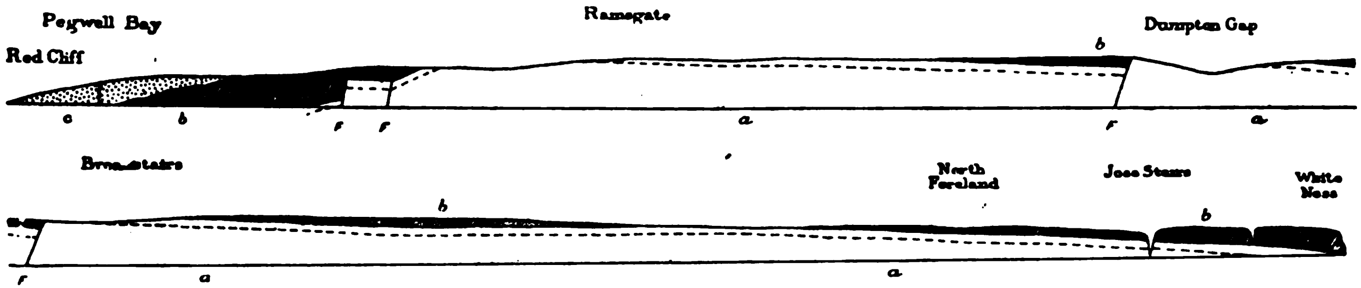

FIG 46.—Section along the coast from Pegwell Bay to White Ness, near Margate.
Hor. Scale, 2 inches to one mile. Vertical Scale, 240 feet to an inch.
c. Thanet Sands. b. Zone of *Marsupites* (Margate Chalk), a. Zone of *Micraster coranguinum*. *F.F.* Faults.
The broken line indicates the position of the 3-inch layer of flint.

in again below Ramsgate, and can thence be traced all the way to Whiteness, though broken here and there by faults. Mr. Whitaker describes it as not "strictly a tabular layer, but rather a continuous bed of nodular flint, as its surfaces are very uneven." According to Mr. Bedwell's measurement, the "three-inch layer" is 21 feet below the yellow nodular bed at the base of the Margate chalk, and 31 feet lower is the thick bed of flint which he named the "columnar band"; while near Ramsgate a further depth of 43 feet of chalk comes in; so that, adding these figures together, we have a thickness of 95 feet of the zone exposed in these cliffs. Dr. Rowe's measurements confirm this estimate, for he says that the three-inch bed is 75 feet from the base of the cliff at Ramsgate, and, adding 21 feet to this, we have a total of 96 feet.

Mr. Bedwell states that the three-inch bed is well known to the local well-sinkers, who say that it occurs throughout the island, and has been proved as far west as Westgate. It must not be assumed, however, that this is the only layer of continuous flint in the higher part of the zone; several others are visible in the cliff, and layers of flint nodules occur with striking regularity, many of them forming floors of closely-packed nodules.

The junction of the flinty chalk of the *M. coranguinum* zone with the almost flintless *Marsupites* zone is best seen at Kingsgate, where the following succession was measured by Professor Barrois :—

	Ft.	*in.*
White chalk without flints.		
Hard yellow nodular bed.		
Chalk without flints - - - - - - - - - -	3	4
Layer of large black flints - - - - - - - -	0	2
Chalk with a few flints - - - - - - - -	6	8
Layer of flints		
Chalk - - - - - - - - - - - -	3	4
Layer of black flints, without white crust		
Chalk with a few scattered flints - - - - - -	3	4
Layer of flints		
Chalk, slightly yellowish, with many fossils - - -	5	0
"Three inch band," a thick bed of tabular flint - -	0	2

3. Margate Chalk, or zone of Marsupites.

The special mineralogical characters of this division of the Chalk have been well described by Mr. Whitaker as follows*:—"The higher division, or, as it may fitly be called, the *Margate Chalk*, contains but a very few nodular flints, so that the bedding is not well shown; and [there are] sometimes thin layers of flint filling the narrow vertical openings of the even joints. These joints, which are very marked and constant in a direction about north-west and south-east, are the cause of the peculiar form of the cliffs in many places near Margate, especially to the west, where there are parallel-sided inlets worn back from the shore, sometimes for some depth into the cliff, and here and there detached masses.

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*Quart. Journ. Geol. Soc., Vol. xxi. p. 396, 1865.

"This division forms the whole of the cliff from the north-western corner of the island to White Ness on the north-east. Between the latter place and Foreness, a distance of about three-quarters of a mile, the face of the cliff is more or less along the joint-lines, [which are] here not quite vertical.

"At White Ness there is a yellowish nodular bed at the bottom of the cliff, which must be at or near the bottom of the Margate Chalk, although there is no marked division between this and the chalk below."[1]

This yellow nodular bed has been taken by subsequent writers as the base of the *Marsupites* zone. Mr. Bedwell states that for 52 feet above it the chalk has no regular lines of flint nodules, only occasional flints here and there. At a certain height, which he estimates as 52 feet, above this base line there is a layer of flints, and he mentions two others in the chalk above, each at a distance of 10 feet from the one below it.

Dr. A. W. Rowe has recently made an elaborate study of the Margate Chalk, and what follows is based on the account which he has published. To the layer of yellowish nodular chalk at the base of the zone he gives the name of "Barrois' sponge-bed," and the layer of flints indicated by Mr. Bedwell he calls the "Bedwell line,"[2] because he finds it to be an horizon of stratigraphical importance.

One of the most notable features of this chalk is the frequent occurrence of large specimens of *Am.* [*Haploceras*] *leptophyllus*, and Mr. Bedwell, who paid special attention to them, found no fewer than eighty-nine *in situ* between Kingsgate and Birchington. The majority of these lay in a band of chalk about 20 feet thick, commencing about 5 feet below his lowest flint layer, which he termed "the guiding line of flints."[3] According to Dr. Rowe, this line of flints is 68 feet above the base (not 52 feet, as stated by Mr. Bedwell), and he informs me that it is really the only horizon at which flints occur in line, and that even here the flints are often at a considerable distance apart.

The importance of this "Bedwell line" is that not only *Am.* [*Hapl.*] *leptophyllus*, but also *Uintacrinus* and *Actinocamax verus*, do not range above it. The "Bedwell line" of flints first comes in at the top of White Ness, which is 68 feet high; thence it gradually sinks westward to the shore-line at the sewer outfall near Foreness Point, where the height of the cliffs is 48 feet. Adding this to the 68 feet below the Bedwell line at White Ness, Dr. Rowe gets the amount of 116 feet for the exposed thickness of the zone, and he has obtained *Marsupites*-plates from the top of Foreness cliff.

From Foreness the " Bedwell line " rises again, till below Hodge's Flagstaff, on Margate Parade, it is 30 feet up in the cliff, and at Fort Point it is 40 feet up. In the cliffs west of Margate it is again seen, at first low down, but gradually rising till, before coming to St. Mildred's Bay, it reaches the top of the cliff. In the headland between that bay and Westgate Bay it is about 30 feet from the cliff-foot, and thence it gradually sinks till, at the west side of Gore-End Bay, it is only 15 feet up, the cliffs there being only about 25 feet high.

Dr. Rowe remarks that, as the flints are few, it is not always easy to follow the " Bedwell line, " and in some places it is quite as easy to follow the line of the *Ammonites* themselves, as in this part of the coast they extend nearly up to the flint-line. In following the " Bedwell line " a valuable aid will be found in a yellow sponge-bed, which occurs with considerable constancy 2 or 3 feet below it, and can be traced throughout the section.

As to the distribution of the fossils, *Marsupites* and *Actinocamax Merceyi* (= *A granulatus*) occur chiefly in the upper beds,but both have been found as low as 30 feet below the " Bedwell line." The pyramidal form of *Echinocorys scutatus* is abundant throughout, but especially just below the " Bedwell line." *Galerites albogalerus* is abundant at and near the base of the zone, and is a rare fossil above the " Bedwell line." Dr. Rowe gives the following scheme of the zone and its principal characteristic ontological features :—

Zone of *Marsupites testudinarius*, 116 feet.	*Marsupites* Band, 48 feet exposed.	*Marsupites testudinarius.* *Actinocamax Merceyi* (= *granulatus*) *Echinocorys vulgaris* (*var. pyramidatus*) *Bourgueticrinus sp. nov.* *Terebratulina Rowei.*
	The Bedwell Line	. . . .
	Uintacrinus Band, thickness 68 feet.	Band of *Echinocorys pyramidatus.* *Uintacrinus.* *Actinocamax verus.* *Ammonites leptophyllus.* *Bourgueticrinus sp. nov.* *Terebratulina Rowei.* Band of *Echinoconus conicus.*
	Barrois, Sponge-bed	v v v v v v v v v v v v

Terebratulina Rowei is a new species described by Dr. Kitchin, and is said by Dr. Rowe to be characteristic of the zone, occurring all through it, and being very rare in any other. *Uintacrinus* is another characteristic fossil, (*see* p. 20).

The inland extension of the *Marsupites* zone has not yet been traced, but Dr. Rowe informs me that it occurs above the cliffs

N.E. of Dover. In a field S.S.W. of St. Nicholas Church at Ringwold, and on the contour line of 200 feet, he found a small exposure which yielded many plates of *Uintacrinus* and nipple-shaped heads of *Bourgueticrinus.*

The occurance of the "Margate Chalk," with very few flints, in the cuttings on the London, Chatham and Dover line, between Sibertswold and Bekesbourn, was noted many years ago by Mr. Whitaker, who records a plate of *Marsupites* as found in one of them.*

LIST OF FOSSILS FROM THE UPPER CHALK OF THE KENTISH COAST.

The following list is based on that recently published by Dr. A. W. Rowe in the paper to which reference has been made. Occurrences recorded by him are indicated by a cross (×); those noted by others are indicated by letters, and the explanation of the letters is as follows:—B=Barrois in his "Recherches sur le Terr. Crét. de l'Angleterre" (1876); D=Dowker, in Geological Magazine, Vol. vii. p. 472 (1870); H=W. Hill in Quart. Journ. Geol. Soc., Vol. xlii. p. 240 (1886).,

———	Zone of Hol. planus.	Zone of M. cortest.	Zone of M. coranguinum.	Zone of Marsupites.
Reptilia.				
Leiodon sp.	–	–	–	x
Polyptychodon sp.	H	–	–	–
Pisces.				
Anomœodus angustus, *Ag.*	–	–	–	x
Belonostomus cinctus ? *Ag.*	–	–	–	x
Beryx (? genus)	x	x	x	x
Cimolichthys lewesiensis, *Leidy*	–	–	x	x
Corax affinis, *Ag.*	–	–	–	x
„ falcatus, *Ag.*	x	x	x	x
„ pristodontus, *Ag.*	–	–	x	x
Enchodus lewesiensis, *Mant.*	–	x	x	x
Lamna appendiculata, *Ag.*	x	x	x	x
Macropoma Mantelli, *Ag.*	–	–	x	x
Notidanus microdon, *Ag.*	–	–	x	x
Oxyrhina Mantelli, *Ag.*	x	x	x	x
Portheus sp.	–	–	–	x
Protosphyræna ferox, *Leidy*	–	–	–	x
Ptychodus mammillaris, *Ag.*	x	x	–	–
„ polygyrus, *Ag.*	x	x	–	x
Scapanorhynchus subulatus, *Ag.*	–	–	x	x
Cephalopoda.				
Am. [Haploceras] leptophyllus, *Sharpe*	–	–	–	x
„ [„] obscurus ? *Schlüter*	–	–	–	B
„ [Placenticeras] obtectus, *Sharpe*	H	–	–	–
„ [Pachydiscus] peramplus, *Mant.*	x	–	–	–
„ [Acanthoceras] cf. Mantelli, *Sow.*	H	–	–	–
Baculites bohemicus, *Fritsch*	x	–	–	–

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* See Mem. Geol. Survey, vol. iv., p. 29 (1872).

	Zone of Hol. planus.	Zone of M. cortest.	Zone of M. coran-guinum.	Zone of Marsupites.
Heteroceras reussianum, *d'Orb.*	x	–	–	–
Scaphites Geinitzi, *d'Orb.*	x	–	–	–
Actinocamax granulatus, *Blainv.*	–	–	–	x
„ verus, *Miller*	–	–	–	x
Nautilus fleuriausianus, *d'Orb.*	H	–	–	–
„ sublævigatus, *d'Orb.*	x	–	–	–
Gasteropoda.				
Aporrhais Mantelli, *Gard.*	x	–	–	–
Avellana Humboldti ? *Müller*	x	–	–	–
Cerithium Saundersi, *Woods*	x	–	–	–
Dentalium turonense, *Woods*	x	–	–	–
Hipponyx sp.	–	–	x	x
Natica vulgaris, *Reuss*	x	–	–	–
Pleurotomaria perspectiva, *Mant.*	H	x	x	–
„ sp. (ornamented)	H	–	–	–
Solarium ?	H	–	–	–
Trochus Schlüteri, *Woods*	x	–	–	–
Solariella gemmata, *Sow.* (=Turbo)	x	x	–	–
Turbo sp.	H	–	–	–
Lamellibranchiata.				
Avicula sp.	–	–	–	x
Inoceramus Brongniarti, *Sow.*	x	x	–	–
„ Cuvieri, *Sow.*	x	x	x	x
„ involutus, *Sow.*	–	x	x	–
„ lingua, *Goldf.*	–	–	–	B
„ mytiloides, *Sow.*	x	x	–	–
„ undulatus ? *Mant.*	–	–	–	–
„ sp.	x	x	–	–
Lima granosa, *Goldf.*	–	–	x	x
„ Hoperi, *Sow.*	x	x	x	x
„ Mantelli, *Brongn.*	–	–	x	x
Ostrea alæformis, *S. Woodw.*	–	–	x	x
„ acutirostris, *Nilss.*	–	–	x	x
„ canaliculata, *Sow.*	x	x	x	x
„ curvirostris, *Nilss.*	–	–	–	x
„ hippopodium, *Nilss.*	x	x	x	x
„ normaniana, *d'Orb.*	x	x	x	x
„ semiplana, *Sow.*	x	x	x	x
„ vesicularis, *Sow.*	x	x	x	x
„ wegmanniana, *d'Orb.*	–	–	–	x
Pecten campaniensis, *d'Orb.*	H	–	–	–
„ cretosus, *Defr.* (=nitidus)	x	x	x	x
„ pexatus, *Woods.*	–	–	–	D
„ undulatus, *Nilss.*	–	–	–	B
„ (Neithea) æquicostatus ? *d'Orb.*	–	–	–	D
„ „ Dutemplei, *d'Orb.*	–	–	x	x
„ „ quinquecostatus, *Sow.*	x	x	x	x
Plicatula Barroisi, *Peron*	x	x	x	x
„ sigillina, *S. P. Woodw.*	x	x	x	x

———	Zone of Hol. planus.	Zone of M. cortest.	Zone of M. coranguinum.	Zone of Marsupites.
Radiolites Mortoni, *Mant.*	–	–	–	x
Spondylus dutempleanus, *d'Orb.*	–	x	x	x
„ latus, *Sow.*	x	x	x	x
„ serratus, *Woods*	–	–	–	x
„ spinosus, *Sow.*	x	x	x	x
Teredo amphisbæna, *Goldf.*	x	x	x	x
Trapezium trapezoidalis, *Rœmer*	x	–	–	–
Brachiopoda.				
Crania egnabergensis, *Retz.*	x	x	x	x
„ parisiensis, *Defr.*	–	x	x	x
Kingena lima, *Defr.*	–	–	x	x
Magas pumilus, *Sow.*	–	–	–	D
Rhynchonella Cuvieri, *d'Orb.*	x	x	–	–
„ limbata, *Schloth.*	–	x	B	x
„ plicatilis, *Sow.*	x	x	B	x
„ „ var. octoplicata, *Sow.*	x	–	–	x
„ reedensis, *Eth.*	x	x	x	x
Terebratula carnea, *Sow.*	x	x	x	–
„ semiglobosa, *Sow.*	x	x	x	x
Terebratulina gracilis, *Schloth.* (var.)	x	x	–	–
„ Rowei, *Kitchin*	–	–	–	x
„ striata, *Wahl.*	x	x	x	x
Thecidium Wetherelli, *Morris*	–	–	x	x
Bryozoa.				
Alecto (Stomatopora) gracilis, *Edw.*	–		–	D
Atagma papularium, *Lonsd.*	–		–	D
Desmepora semicylindrica, *Lonsd.*	H	–	–	–
Diastopora (Proboscina) ramosa, *Edw.*	–	–	–	D
Marginaria Rœmeri ? *Lonsd.*	–	–	–	D
Pustulipora pustulosa, *Lonsd.*	H	–	–	D
Vincularia leda, *d'Orb.*	H	–	–	–
Crustacea.				
Enoploclytia Leachi, *Mant.*	x	x	x	x
Pollicipes glaber, *Roemer*	–	–	x	x
Scalpellum fossula, *Darw.*	–	x	x	x
„ maximum, *Sow.*	x	x	x	x
Crinoidea and Asteroidea.				
Antedon Lundgreni, *Carp.*	–	–	–	x
Antedon perforata, *Carp.*	–	–	–	x
„ striata, *Carp.*	–	x	–	x
Bourgueticrinus ellipticus, *Miller*	–	–	?	?
„ sp.	–	–	–	x
Marsupites testudinarius, *Schloth.*	–	–	–	x
Mitraster Parkinsoni, *Forbes*	–	–	x	–
„ uncatus, *Forbes*	–	–	–	x
Ophiura sp.	–	–	x	x
Oreaster Boysi, *Forbes*	–	–	–	D
„ obtusus, *Forbes*	–	–	–	x
„ pistilliferus, *Forbes*	–	–	–	D

———	Zone of Hol. planus	Zone of M. cortest.	Zone of M. coranguinum.	Zone of Marsupites.
Pentacrinus sp. - - - - - - - -	x	x	x	x
Uintacrinus westfalicus, *Schlüter* - - -	–	–	–	x
Echinoidea.				
Cardiaster ananchytis, *Goldf.* - - - - -	x	x	–	–
Cidaris clavigera, *König* - - - - - -	x	x	x	x
„ hirudo, *Sorig.* - - - - - -	x	x	x	x
„ perornata, *Forbes* - - - - -	x	x	x	x
„ sceptrifera, *Mant.* - - - - -	x	x	x	x
„ serrifera, *Forbes* - - - - -	x	x	x	–
Cyphosoma corollare, *Klein* - - - - -	–	–	x	x
„ Kœnigi, *Mant.* - - - - -	–	x	x	x
„ radiatum, *Sorig.* - - - - -	x	x	x	x
„ spatuliferum, *Forbes* - - - -	–	–	x	x
Discoidea Dixoni, *Forbes* - - - - -	x	–	–	–
Echinocorys scutatus, var. gibbus, *Lam.* -	x	x	–	–
„ „ var. ? - - - - -	–	–	x	–
„ „ var. pyramidatus - -	–	–	–	x
Epiaster gibbus, *Lam.* - - - - - -	–	x	x	x
Galerites albogalerus, *Leske* - - - - -	–	x	x	x
„ globulus, *Desor* - - - - -	–	–	–	x
Hemiaster minimus, *Ag.* - - - - -	x	x	–	–
Holaster planus, *Mant.* - - - - - -	x	x	–	–
„ placenta, *Ag.* - - - - - -	x	x	x	–
Infulaster (Hagenowia) rostratus, *Forbes* - -	–	–	x	x
Micraster coranguinum, *Leske* - - - -	–	–	x	x
„ corbovis, *Forbes* - - - - - -	x	–	–	–
„ cortestudinarium, *Goldf.* - - -	x	x	x	–
„ Leskei, *Desm.* - - - - - -	x	–	–	–
„ præcursor, *Rowe* - - - - -	x	x	x	–
Offaster pillula, *Lam.* - - - - - -	–	–	–	x
Salenia geometrica, *Ag.* - - - - -	–	–	–	x
„ granulosa, *Forbes* - - - - -	x	x	x	x
Zeuglopleurus Rowei, *Greg.* - - - - -	–	–	x	x
Annelida.				
Serpula ampullacea, *Sow.* - - - - -	x	x	x	x
„ fluctuata, *Sow.* - - - - - -	x	x	x	x
„ granulata, *Sow.* - - - - - -	x	x	x	x
Serpula ilium, *Sow.* - - - - - - -	x	x	x	x
„ macropus, *Sow.* - - - - - -	x	x	x	x
„ plana, *Woodw.* - - - - - -	x	x	x	x
„ plexus, *Sow.* - - - - - -	x	x	x	x
„ turbinella, *Sow.* - - - - - -	–	–	x	x
Actinozoa.				
Axogaster cretacea, *Lonsd.* - - - - -	–	x	x	x
Caryophyllia cylindracea, *Reuss* - - -	H	–	–	x
Cœlosmilia laxa, *Ed. and H.* - - - - -	–	–	–	x
Epiphaxum auloporoides, *Lonsd.* - - -	x	x	x	–
Parasmilia centralis, *Mant.* - - - - -	x	x	x	x
„ „ var. gravesiana, *Ed. and H.* -	–	–	x	x
„ Mantelli, *Ed. and H.* - - - -	–	–	x	–

———	Zone of Hol. planus.	Zone of M. cortest.	Zone of M. coranguinum.	Zone of Marsupites.
Parasmilia cylindrica, *Ed. and H.*	–	–	x	–
„ Fittoni, *Ed. and H.*	–	–	–	x
„ granulata, *Duncan*	–	–	x	x
Onchotrochus serpentinus, *Duncan*	–	–	x	–
Stephanophyllia Michelini, *Lonsd.*	–	–	x	x
Spongida.				
Camerospongia aperta, *Hinde*	x	–	–	–
„ campanulata, *T. Smith*	H	–	–	–
„ subrotunda, *Mant.*	x	–	–	–
Cephalites Benettiæ, *Mant.*	x	x	–	–
„ catenifer, *T. Smith*	H	–	–	x
„ longitudinalis, *T. Smith*	x	–	x	x
Cliona cretacea, *Portl.*	x	x	x	x
Coscinopora infundibuliformis, *Goldf.*	x	x	x	x
Craticularia Fittoni, *Mant.*	x	x	–	–
Doryderma ramosum, *Mant.*	x	x	x	x
Guettardia stellata, *Mich.*	x	x	x	x
Heterostinia obliqua, *Benett.*	x	x	x	x
Leptophragma Murchisoni, *Goldf.*	x	x	x	x
Ophiraphidites anastomosans, *Hinde*	–	–	x	x
Pachinion scriptum, *Roemer*	x	x	x	x
Pharetrospongia Strahani, *Sollas*	x	x	x	x
Pholidocladia ramosa, *Hinde*	x	x	x	x
Placotrema cretaceum, *Hinde*	x	x	x	x
Plinthosella compacta, *Hinde*	x	x	x	x
„ nodosa, *Hinde*	–	–	x	x
„ squamosa, *Zitt.*	x	x	x	x
Plocoscyphia convoluta, *T. Smith*	x	x	x	x
„ labrosa, *T. Smith*	x	x	x	x
Polyblastidium racemosum, *T. Smith*	–	–	x	x
Porochonia simplex, *T. Smith*	–	–	x	x
Porosphæra globularis, *Phil.*	x	x	x	x
„ pileolus, *Lam.*	x	x	x	x
„ Woodwardi, *Carter*	x	x	x	x
Siphonia Kœnigi, *Mant.*	x	x	x	x
Steletta inclusa, *Hinde*	x	x	–	x
Stichophyma tumidum, *Hinde*	x	x	x	x
Toulminia sp.	–	–	–	x
Tremabolites perforatus, *T. Smith*	H	–	–	–
Ventriculites convolutus, *Hinde*	–	–	x	x
„ cribrosus, *Phil.*	x	x	x	x
„ decurrens, *T. Smith*	x	x	x	x
„ impressus, *T. Smith*	x	x	x	x
„ infundibuliformis, *S. Woodw*	x	x	x	x
„ mammillaris, *T. Smith*	x	x	x	x
„ radiatus, *Mant.*	x	x	x	x
Verrucocœlia tubulata, *T. Smith*	–	–	x	x

CHAPTER XII.

THE UPPER CHALK IN THE WESTERN PART OF KENT.

GENERAL REMARKS.

The Chalk of Kent has not yet been re-examined by any member of the Geological Survey, and though Mr. Hill has traced the lower zones along the escarpment the only district where he has had an opportunity of examining the higher zones is that of Rochester and Chatham.

The bed which we have taken as the base of the zone of *Holaster planus*, and therefore of the Upper Chalk, is one in which flints are thickly but irregularly scattered. Below it flints are scarce and above it they are frequent; moreover, *Echinocorys scutatus* never occurs below this bed, but comes in very soon above it. It may not continue to be exactly on the horizon of the bed which we have taken as the base near Dover, and it is usually thinner, but it seems to represent that bed and also to be fairly persistent.

Above it the chalk consists for the most part of hard compact and semi-crystalline lumps embedded in a softer mealy kind of chalk; in weathered faces these hard lumps are conspicuous as knobby projections, and at irregular intervals there are beds of cream-coloured nodules or lumps of indurated chalk, and occasionally courses of hard compact limestone, much resembling the Chalk Rock of Midland counties.

As in the coast section, the division into zones of *Holaster planus* and *Micr. cortestudinarium* is more imaginary than real, and in most places the one zone seems to pass into the other. Between them, however, they include all the rough lumpy chalk, and near Chatham they seem to have a clearly marked upper limit in a bed of compact limestone, which serves, at any rate locally, to divide the zone of *M. cortestudinarium* from that of *M. coranguinum*. Fortunately the chalk quarries at Chatham have been well searched by Mr. W. Gamble, and from him we have been able to obtain a collection of fossils which must fairly represent the fauna of the *M. cortestudinarium* zone.

The chalk of these two zones of *Holaster planus* and *Micraster cortestudinarium* has a thickness of over 100 feet.

With respect to the zones which are present in the western part of Kent no very certain evidence has hitherto been forthcoming. The larger number of the pits appear to be opened in the zone of *Micraster coranguinum*, and no plates of *Marsupites* have yet been recorded from this part of the county. On the other hand, two *Belemnites* occur at Gravesend and Cliffe, namely, *Actinocamax granulatus* and *Act. verus*, both of which are common in the *Marsupites* Chalk of Margate.* It is possible, therefore, that the zone of *Marsupites* is represented at these places, but Dr. Rowe is of opinion that the Chalk of Gravesend belongs to the zone of *M. coranguinum*.

As to the thickness of Upper Chalk in West Kent there is no certain knowledge, but the total thickness of the Chalk has been determined by several borings, and from the records of them some idea of the thicknesses of the three divisions can be obtained. Two borings at Chatham Dockyard give a total thickness of 682 to 689 feet for the Chalk,† and this is believed to include the full local thickness. The following details are recorded of the Chalk in one of these borings:—

		Ft.	*in.*
Upper Chalk.	Soft chalk, with a layer of flints at bottom -	43	1
	Block chalk, with many layers of flints - -	80	3
	Hard rocky material, called "white flint" -	2	9
	Chalk with many layers of flints - - -	139	1
Middle and Lower Chalk.	Hard chalk (no particulars given), this probably includes the zones of *Terebratulina* and *Rhynch. Cuvieri* - - - - - -	234	10
	Chalk and Chalk Marl - - - -	189	0
		689	0

This gives a thickness of 265 feet for the Upper Chalk near Chatham, but more chalk probably comes in to the north of that place.

A boring at Crossness was made in 1877, and in the original account the thickness of Chalk is given as 631, with 65 feet of "Upper Greensand" below, but, as Mr. Whitaker remarks,‡ "probably the greater part belongs to the Chalk Marl"; considering indeed the proved thickness of the Chalk at Chatham and the nature of the beds at the outcrop near Otford, it is probable that all but 5 or 6 feet belongs to the Chalk Marl, hence we may conclude that the total thickness of the Chalk at Erith is about 690 feet. No particulars respecting the successive beds of chalk traversed by this boring have been preserved, but in another boring made in 1875, at Belvidere, in Erith Marshes, and recorded by Mr. Whitaker (op. cit. p. 60), over 300 feet of chalk were penetrated, and full particulars were supplied by Messrs. T. Docwra and Son. In a condensed form these may be stated as follows :—

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* *Belemnitella mucronata* has been quoted as occurring in the chalk of Gravesend and Northfleet, but Mr. Newton informs me that this is a mistake, the specimens being really *Bel. lanceolata*, which has a greater range than *Bel. mucronata*.

† Published by Mr. W. Whitaker in a paper "On some borings in Kent," Quart. Journ. Geol. Soc., Vol. xlii., p. 28 (1886).

‡ Geology of London, Vol. ii. p. 67, Mem. Geol. Survey (1889).

	Ft.	*in.*
Base of Eocene at 145½ feet.		
Chalk with few flints	61	6
Chalk with many flints	56	9
Rock Chalk	1	6
Soft Chalk with many layers of flints	97	0
Chalk rock (*i.e.*, hard calk)	1	6
Chalk with flints	17	9
Grey marl	1	3
Chalk with flints	32	3
Alternating hard and soft beds, described as sandstone, grey marls, marly chalks and bluish rock-beds	45	0
	314	6

The lowest 45 feet may be part of the zone of *Micraster cortestudinarium*; the overlying chalk with flints must represent the zone of *M. coranguinum* (208 feet), and the uppermost 61½ feet is probably the same chalk as that which is exposed at Cliffe and Gravesend.

In dealing with the stratigraphical details of the inland areas it will be convenient to take the Upper Chalk in two divisions, following first the beds below the *M. coranguinum* zone, and then those of and above that zone.

STRATIGRAPHICAL DETAILS.

A. Zones of Holaster planus and Micraster cortestudinarium.

A good exposure of the basal beds of the Upper Chalk was seen in a quarry 300 yards west of St. Lawrence Church, Godmersham, the section being as follows :—

		Ft.	*in.*
Soil and rubble		2	0
Zone of Holaster planus.	Firm white chalk, weathering near the surface in thin platy pieces, containing three layers of flints, *Hol. planus*	8	0
	A marked layer of large flints	0	9
	Rather rough lumpy white chalk	2	6
	Bed of small scattered flints	1	0
	Smooth firm chalk without flints	1	0
	Hard white chalk with many scattered flints, at the base a marked bed of hard cream coloured nodules, rusty coloured exteriorly, *Hol. planus*, *Micraster* sp., *Ter. carnea*	2	6
	Rough lumpy white chalk with a few flints	4	6
	A layer of cream coloured nodules	1	0
	Rough lumpy chalk with very few flints	5	0

Terebratulina zone.	A well marked marly layer - - -	0	6
	A course of massive smooth white firm chalk -	2	0
	A line of large flints - - - - - - -	1	0
	Smooth firm white chalk with a few smallish flints - - - - - - seen for	6	0
	Total	37	9

At the Warren Quarry, two-thirds of a mile N.N.W. of All Saints Church, Boughton Court, the section was as follows:—

		Ft.	*in.*
Soil	- - - - - - - - - - - -	1	–
Zone of *Holaster planus*.	Rough lumpy creamy yellow coloured chalk with scattered flints, *T. carnea*, *Rhynchonella* sp. *H. planus*, *Micraster* sp. - - -	14	0
	Course of smoother white chalk - - -	1	6
	Layer of flints - - - - - - - -	0	9
	Rough lumpy chalk, hard lumps in a matrix of mealy chalk no flints - - -	3	0
	Marl band - - - - - - - -	0	6
	Rough lumpy chalk with a few scattered flints -	3	0
	Thin seam of marl - - - - - - -		
	Rough lumpy chalk with many flints especially in the lower 3 feet - - - - - - -	5	6
Zone of *Terebratulina*.	Massive bedded, firm white chalk with a few scattered flints - - - - - - -	9	0
	A marl band - - - - - - - - -	0	6
	Massive firm white chalk with a few small scattered flints - - - - seen for	16	0
	Total	54	9

Exposures of the chalk in the zone of *Holaster planus* occur in a quarry on the top of the Downs, one-third of a mile south-south-east of Cold Blows Farm, and in the upper part of the quarry, at Harp Farm, near Bosley. The base of this zone is possibly also seen in the top of the quarry at the Lower Bell Inn, but in 1896 this part of the face was not accessible. In the highest quarry near the main road, just beyond Kits Coty House, on Blue Bell Hill, the chalk exposed is probably the base of the zone of *H. planus*, while a small roadside pit, some 300 yards south of the Upper Bell Inn—Blue Bell Hill—must be in the zone of *M. cortestudinarium*, as a specimen of the typical form was obtained there.

The Upper Chalk quarry of the Burham Brick and Lime Company on Blue Bell Hill, gives a section of nearly the whole of the zones of *Holaster planus* and *Terebratulina*. The method of working, the insecurity of foothold, and the great height of the face of this and other quarries in the Medway Valley make it rather difficult to obtain an exact measurement, but as far as could be ascertained, the section was as follows in 1896. Doubtful points were checked again in 1897, and roughly compared again in 1898. The point at which the section was taken was not quite the highest in the quarry.

		Ft.	*in.*
Zone of *Holaster planus*, 52 feet.*	Very rough rubbly hard crystalline chalk, weathering at the surface in platy fragments; some flints. *Micraster corbovis*, *Hol. planus*, *Echinocorys scutatus* - - - - - about	20	0
	Rough lumpy chalk, uneven texture, scattered flints, *Echinocorys scutatus* - - - - -	16	0
	Layer of flints - - - - - - - - -	0	6
	Massively bedded chalk, not quite so rough as that above but few scattered flints - -	5	0
	Layer of flints - - - - - - - - -	0	6
	Rough hard lumpy chalk in one rather massive bed - - - - - - - - -	3	6
	Layer of flints - - - - - - -	0	6
	Rather rough and lumpy chalk, but not so rough as that above. *Micraster* sp. - -	3	0
	Rather rough hard chalk with many scattered flints, at some points along the face the flints seem arranged in two layers, one at top and one at the bottom of this course, at others they are thickly scattered through the bed -	3	0
Zone of *Terebratulina*.	Firm smoother white chalk - - - - -	4	0
	Firm white smooth chalk, with a bed of hardish iron stained lumps, about 10 feet down, a few scattered flints, and 3 or 4 indefinitely marked layers - - - -	25–30	0
	Massive homogeneous white chalk with occasional seams of soft marl from the lowest flint line to the floor of the quarry—measured in 1896 - - - - - - -	117	0
		198	0

Another large quarry called Bores Hole, on the eastern bank of the Medway, at Whorn's Place, three-quarters of a mile south-west of Cuxton Station, exposes the upper part of the Middle Chalk. In 1896 the whole of the upper part of the quarry was inaccessible, but the perpendicular face enabled one to see the succession from the upper part of the *Terebratulina* zone to the zone of *Micraster cortestudinarium*. The bed of flints at the base of the zone of *Holaster planus* was well seen, and the chalk above it presents a contrast to that below in the abundance of flints which occur, not only as scattered nodules, but in layers at short distances apart; there are also one or two layers of tabular flint near the top of the quarry.

In 1898 it was possible to measure a certain portion of the face from the top of the *Terebratulina* zone through that of *Holaster planus*, and this, in conjunction with the two quarries to be

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*A part of this is probably in the zone of *M. cortestudinarium*, but we are inclined to estimate the thickness of the zone of *H. planus* in this district as from 40 to 45 feet.

mentioned next, gives a section through the zones both of *H. planus* and *M. cortestudinarium*. It is as follows :—

		Ft.	*in.*
Zone of *Holaster planus* ; 37 feet.	White chalk of rather irregular texture, somewhat mealy to the touch, and the lumpy character not so evident as is frequently the case; layers of flints alternate with courses of the chalk, each course being from 1ft. 6in. to 2ft. 5in. *Hol. planus* and *Ter. semiglobosa*	16	0
	White chalk, texture irregular, lumpy	1	6
	Layer of flint	0	4
	White chalk in two courses	3	0
	A well marked layer of flints	0	9
	White chalk as before in two courses no flints	5	5
	A marly layer not well marked	0	2
	A massive course of white chalk, no flints	2	6
	Course of white chalk, separated from that above by a thin weak layer of tabular flint	1	6
	Layer of flints	0	4
	White chalk of irregular texture, lumpy, containing a few scattered flints	1	3
	Layer of flints	0	4
	A course of rather rough lumpy chalk with a few scattered flints	2	6
	Rough lumpy chalk with many scattered flints, inclined to a definite layer at top	2	0
Zone of *Terebratulina.*	Rough lumpy chalk in two courses, with but few flints	5	0
	Firm blocky chalk with three or four layers of flints in the upper part	+50	0

From the lower ten feet of the zone of *Hol. planus* Mr. Rhodes obtained *Holaster planus*, *Micraster Leskei*, *Cyphosoma radiatum*, *Rhynchonella plicatilis* and a few other fossils.

On the opposite side of the river and west of Borstal is another quarry called the Borstal Manor Pit; this is about 70 feet deep and shows a similar section through the upper part of the *Terebratulina* zone and the greater part of the *Hol. planus* zone. Mr. Gamble, of Chatham, collected fossils for me from the *H. planus* zone here in 1901, and the species obtained are included in the list on p. 168. He also obtained fossils from the trench round Borstal Fort which seem to indicate the zone of *M. cortestudinarium* at that spot. They include *Micraster præcursor*, *M. cortestudinarium*, *Salenia granulosa*, *Cidaris clavigera*, *Echinocorys scutatus*, *Crania parisiensis*, *Lima Hoperi*, and others.

At Messrs. Booth's quarry, a quarter of a mile north-east of Cuxton Station, the upper part of the section at Bores Hole quarry is repeated. We think the quarry floor is just above the horizon of the base of the zone of *Holaster planus*. The following measurement of the whole face of the quarry was taken in 1896. The quarry was visited again in 1898, when the face was seen to have been cut back considerably :—

		Ft.	*in.*
Zone of *M. cortestudinarium.*	Softish white chalk - - - - - - -	6	0
	Line of tabular flint - - - - - - -	0	2
	White softish chalk with scattered flints - -	7	0
	A well-marked bed of creamy yellow coloured lumps in softer matrix, the lumps iron-stained exteriorly - - - - - - - - - -	1	0
	White chalk of irregular texture, hard and lumpy in some places, softer in others, with layers of flints and a few scattered - - - - - -	10	0
Zone of *Holaster planus.*	A course of hard lumpy yellowish chalk like that above - - - - - - - - -	1	0
	Rather rough lumpy chalk with flints scattered and in lines, no very well marked harder course	21	0
	A well-marked layer of flints - - - - -	0	9
	Two massive courses of chalk divided by a thin marl seam, a discontinuous layer of flint near the base, *Echinocorys scutatus* - - -	7	6
	A well-marked layer of flints - - - - -	0	9
	White lumpy chalk with scattered flints, more numerous near the base - - - - - -	3	0
	Softish white chalk with scattered flints - -	4	0
	About	62	0

The upper beds are doubtless referable to what has been called the zone of *Micraster cortestudinarium,* but it is difficult to say how much should be assigned to it. Mr. Rhodes was sent to collect here, but could only obtain fossils from the beds between 16 and 26 feet above the floor of the pit. These were *Micraster Leskei, M. præcursor, Holaster planus, and Ptychodus latissimus.*

The next quarry along the left bank of the Medway is Messrs. Martin and Earl's, about a third of a mile north-eastward of the last; most of the chalk here exposed belongs to the zone of *M. cortestudinarium.* The description given below was taken in the spring of 1897. A few fossils were subsequently found here by Mr. Rhodes, and have been inserted :—

		Ft.	*in.*
Zone of *Micraster coranguinum.*	White soft chalk with flints in beds or layers -	22	0
	A course of slightly harder chalk marked by iron stains - - - - - - - - - -	1	0
	White soft chalk with layers of flints, *Terebratula carnea* and *Echinocorys scutatus* - - -	7	0
Zone of *Micraster cortestudinarium.*	A bed of very hard creamy yellow coloured crystalline chalk, not nodular, but with green-coated nodules at the top, which was sharply marked from the chalk above - - - -	1	3
	White softish chalk with layers of flints - -	5	0
	A discontinuous bed of hard whitish but much iron-stained chalk, *Micraster præcursor* -	1	0

		Ft.	in.
Zone of *Micraster cortestudinarium.*	Exceedingly rough lumpy chalk, lumps well defined, enclosed in soft mealy matrix; few scattered flints, *M. præcursor*, *Spondylus spinosus*	8	0
	White chalk of rather irregular texture, lumpy, with layers of flints	5	0
	Layer of tabular flint	0	2–3
	Firm white chalk with layers of flints, scarcely lumpy, *Holaster placenta*, *Micraster præcursor*	16	0
	A discontinuous bed of hardish lumpy chalk, much iron stained, *Echinocorys scutatus*	1	0
	Layer of tabular flint	0	1
	Firm white chalk with layers of flints	10	0
		77	6

Another good section of the *M. cortestudinarium* zone is to be found in John Dunstall's quarry, near the railway at Chalk Hill, Chatham. This was visited in 1899:—

	Ft.	in.
Soil and chalk rubble	6	0
Soft white chalk, *Micraster cortestudinarium* and *Echinocorys scutatus*	4	0
Hard rather lumpy yellowish crystalline chalk, rubbly at top, inclined to be nodular, hardly a solid bed	1	3
Soft white chalk	2	6
A layer of lumpy chalk, hard lumps, slightly iron stained, in soft mealy matrix about	1	0
White chalk, rather firmer, but with layers of soft chalk; layers of black flints about 3 feet apart	30	0
A well-marked layer of flint nodules	0	6
Softish white chalk, *Echinocorys scutatus*	3	6
A marked layer of tabular flint, which dies away rapidly to the east and west	0	3
White rather firm chalk with a few flints more or less in layers, *Echinocorys scutatus* and *Micraster præcursor*	5	6
White chalk with many scattered flints (a flint bed)	1	0
White rather firm chalk, *Micrasters*	3	6
Bed of flints as before	1	0
Chalk seen for	3	0
About	63	0

The Micrasters obtained here all belong to what Dr. Rowe calls the *præcursor* group. Their ambulacra are distinctly divided and tubercular; they are certainly *not* true *M. coranguinum*, and one obtained by Mr. Rhodes is a typical *M. cortestudinarium*. Mr. Gamble has also obtained *Holaster placenta* from the base of this quarry, and many other fossils partly from this quarry and partly from that next mentioned.* (For a list of these, see p. 168.)

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*Mr. Gamble informs me that the view of this quarry given by Mr. Vine in his report on Cretaceous Polyzoa (Brit. Assoc. Rep., Sect. C., 1892, p. 6) is incorrect, as it includes details taken from this and the pits on Chatham Hill.

On the southern side of Chatham Hill, near the hamlet of Luton, are three quarries, all of which give good sections of what we regard as the junction of the *M. cortestudinarium* and the *M. coranguinum* zones. The following are particulars of the beds seen in the middle quarry (disused in 1899), from which Mr. Gamble has obtained many fossils:—

Zone	Bed	*Ft.*	*in.*
Zone of *M. coranguinum.*	Soft white chalk with flints, here inaccessible -	35	0
	Soft blocky chalk with a few scattered flints - -	5	0
	Layer of large flints - - - - - - -	0	6
	Firmer white chalk with a few scattered flints -	5	0
	Rough lumpy chalk, consisting of hard lumps in a softer matrix - - - - - - - -	1	1
Zone of *M. cortestudinarium.*	C. Very hard compact yellowish limestone, rough at top and perforated with tubular hollows, no marked base - - - - - -	1	3
	Nodular chalk, hard lumps in a softer matrix, a layer of flints about 2 feet down - -	3	0
	Rather soft white chalk with some flints - -	3	9
	Layer of large flints, greyish-black inside -	0	4
	Soft white chalk with layers of small flints -	4	6
	Rough white lumpy chalk - - - -	3	0
	B. Bed of yellowish nodular chalk with softer chalk between the nodules - - - -	1	0
	Soft white chalk with two marked layers of flints - - - - - - - - -	8	6
	A. Bed of hard yellowish nodules in a softer matrix - - - - - - - - -	1	0
	Rough lumpy chalk - - - - - -	1	3
	Bed of nodules (paler yellow) in soft matrix -	1	0
	Softer white chalk with layers of flints - -	18	0
	About	93	0

We are inclined to take the highest limestone bed as the top of the *M. cortestudinarium* zone, because it seems to be the highest hard bed in the district, and because the chalk below has many nodular beds, which contain Micrasters of the *præcursor* group, and of the type characteristic of the *M. cortestudinarium* zone, one identifiable as *M. cortestudinarium* being obtained just below the limestone. The bed of yellow nodular chalk marked *A* is similar to that near the top of Dunstall's pit, so that these two quarries may give a continuous succession. We cannot, however, be sure that the bed C is the same as that taken at the top of the zone in Martin and Earl"s quarry. We are inclined to put the thickness of the zone of *M. cortestudinarium* as from 75 to 80 feet.

Another quarry, about 300 yards to the west of the above section, shows the yellowish limestone about 10 feet above the floor, and above this about 60 feet of the *M. coranguinum* zone.

The three conspicuous layers of yellow nodular chalk are visible in the road-cutting up Chatham Hill.

Professor Hughes has recorded a section in the cliff on the north-east bank of the Medway in Limehouse Reach, which evidently includes one of these hard beds* ; not having seen this exposure we cannot say which of the three, but should suppose it to be the highest. The following is the figure and description given by Professor Hughes :—

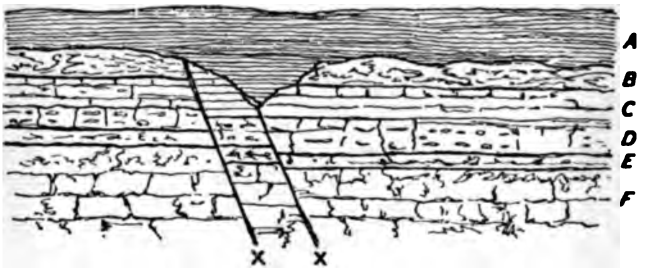

FIG. 47.—Section in Limehouse Reach, Rochester.

	Ft.	in.
A. Surface soil - - - - - - - - - -	3	0
B. Discoloured chalk rubble - - - - - - -	2	6
C. Thin bedded chalk with a few flints - - - - -	2	6
D. More compact thin-bedded chalk, the middle thickly but irregularly set with flints - -	3	0
E. Hard chalk, weathering into knobs and containing many fossils, sharply divided from the bed below -	1	3
F. Chalk like that above, but passing down into more thickly bedded and jointed chalk with few flints -	2	0

The beds are displaced by two small faults (× ×.) with a throw of about a foot. The hard bed may also correspond with that seen in Martin and Earl's pit in Wickham Reach.

Zones of Micraster coranguinum and ? Marsupites.

The fine quarries on Chatham Hill show from 50 to 60 feet of chalk above the layer of compact yellow limestone; this chalk is soft and contains many layers of flints, including one conspicuous layer of large flints. The Micrasters which occur are like those which occur in the lower part of this zone on the coast.

A quarry at Gadshill, half a mile east of Gillingham church, is about 70 feet deep in soft chalk with many layers of flints, evidently belonging to the same zone.

The large quarry east of Stroud, and known as Frindsbury Limeworks is probably 100 feet deep, and is cut entirely in the M. *coranguinum* zone, showing soft, featureless white chalk with many layers of flints. From the lower 14 feet of this Mr. Rhodes obtained some fossils, identified by Messrs. Newton and Kitchin as follows, and three marked G were obtained by Mr. Gamble :—

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* In Vol. iv. of the Memoirs of the Geol. Survey, p. 28 (1872).

Ptychodus rugosus, *Eg.*
Inoceramus (fragment).
(G) „ Brongniarti, *Sow.*
Terebratula semiglobosa, *Sow.*
„ sp. (? new).
Rhynchonella limbata, *Schloth.*
Onchotrochus serpentinus, *Dunc.*

Bourgueticrinus ellipticus, *Miller*
Cidaris hirudo ? *Sorig.*
„ clavigera, *König*
(G) „ sceptrifera, *Mant.*
Echinocorys scutatus, *Leske*
Micraster coranguinum, *Leske*
(G) „ præcursor, *Rowe*

Mr. G. E. Dibley records a specimen of *Actinocamax granulatus* with *Galerites albogalerus* and other fossils from this quarry.

North-east of this and close to the cement works at Whitewall Creek, there is the weathered face of an old quarry which seems to show the highest beds of the *M. coranguinum* zone. The chalk is soft and white, with many layers of flints, and some scattered nodules ; fossils occur in some abundance, and Mr. Hill in a short time collected *Micraster coranguinum* (high-zonal type), *Galerites albogalerus*, *Gal. globulus* ? and many spines of *Cidaris sceptrifera*. In the rubble at the top of the cliff face he found some lumps of yellow chalk like those in the quarry mentioned below. Mr. Rhodes, subsequently collecting here, added the following species : *Echinocorys scutatus*, *Inoceramus*, *Terebratula semiglobosa*, and *Serpula granulata*.

In a quarry about a mile N.W. of Frindsbury Mr. Hill saw a bed containing lumps of indurated chalk with a yellowish coating which impressed him as resembling the bed occurring at the base of the *Marsupites* zone near Margate, a section which he had just previously examined. Such yellow-coated lumps are not known at any other horizon in the Upper Chalk of Kent, but there is no reason why they should not occur at other horizons, and it would not be safe to assume that the actual junction of the two zones is exposed in this quarry merely from the occurrence of a similar nodule-bed.

The quarry is at the point where Stone House Lane enters the main road, and the succession seen in it by Mr. Hill was as follows :—

	Feet.
Soil and broken chalk - - - - - - -	4
Rather firm chalk of a yellowish tint with here and there a large flint, and at the base many lumps or large nodules of hard chalk with a yellowish crust - - - - -	4½
Firm white chalk with *Galerites globulus*, *Echinocorys scutatus*, etc. - - - - - - - - - - -	3
Softer white chalk with scattered flints - - - - -	4
Soft white chalk with very few flints (*Micraster coranguinum*)	11
A marked layer of flints - - - - - - - - -	½
Chalk with layers of flints - - - - seen for	6 to 8
	About 34

The upper part of this zone is probably exposed in the railway cutting at Higham, of which a sketch has been given by Mr. Whitaker,† and is reproduced in Fig. 48.

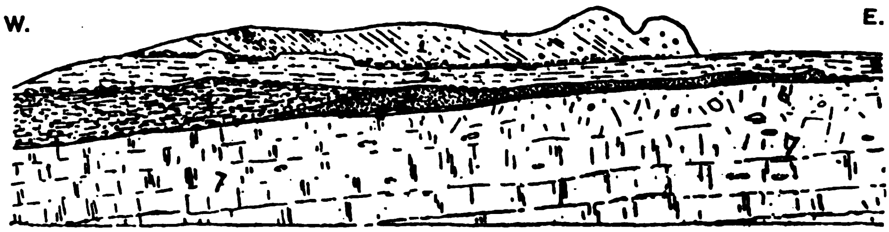

FIG. 48.—Section in the cutting at Higham Station.

1. Spoil heap from the railway tunnel.
2, 3, 4. Drift deposits and reconstructed Eocene.
5. Layer of flints forming base of the Thanet Sand.
6. Disintegrated and rubbly chalk.
7. Chalk with a few large flints scattered through it.

The beds dip to the north-west at angles increasing from 2° to 6°.

North-east of Higham there is an inlying area of chalk which extends to the village of Cliffe, and in this one would expect to find traces of the zone of *Marsupites*. The quarries at Cliffe have been recently visited by Mr. G. E. Dibley, who describes the chalk seen as soft and friable, with some layers of flints, and exposed for about 70 feet. He did not find either *Uintacrinus* or *Marsupites*, but says "the carinated form of *Micraster coranguinum*, also *Echinoconus conicus*, *Cyphosoma Kœnigi*, *Actinocamax verus*, and *A. Merceyi* (=*granulatus*) are common, and *A. westfalicus* has been obtained." *

Chalk which probably belongs to the same horizon has been worked for many years by Gravesend, Northfleet and Greenhithe, from 30 to 40 feet being quarried beneath the Thanet Sand. Here also there are occasional layers of flints and a continuous seam of flint. Mr. G. E. Dibley has published a note on the chalk in Messrs. Fletcher and Co.'s quarry,‡ and states that both *Actinocamax verus* and *A. granulatus* are found there, but that no plates of *Marsupites* have yet been discovered. The fossils mentioned by Mr. Dibley are included in the list on p. 168.

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* See Proc. Geol. Assoc. Vol. xvi., p. 488.

† Geology of London, Vol. i., p. 121, Mem. Geol. Survey (1889).

‡ Proc. Geol. Assoc., Vol. xv. p. 463 (1898), and Vol. xvi. p. 489.

It is probably the same chalk on which the Eocene rests at Erith and Crayford, a layer of continuous flint occurring at both places about 12 or 15 feet from the top of the chalk, see Whitaker (Op. cit., p. 113).

We have no information respecting the exposures of Upper Chalk between the valleys of the Medway and the Darent, but the zone of *Micraster coranguinum* must occupy some breadth of country to the south of the railway from Stroud to St. Mary Cray.

Mr. Whitaker* has described the chalk-pits at and near Chiselhurst. One in the middle of Camden Park formerly showed as much as 20 feet of chalk, and was worked by means of galleries driven in beneath a bed of hard chalk which served as a roof-bed; and an old note by Dr. Mitchell states that the chalk was worked down to another hard bed which formed a floor about 20 feet from the top of the chalk. In another pit west of Chiselhurst church Mr. Whitaker found the same hard beds, and he notes also that the chalk has layers of very large flints, sometimes as much as 18 inches thick, and one of these layers being close to the top. All this is suggestive of the chalk here belonging to the zone of *M. coranguinum.*

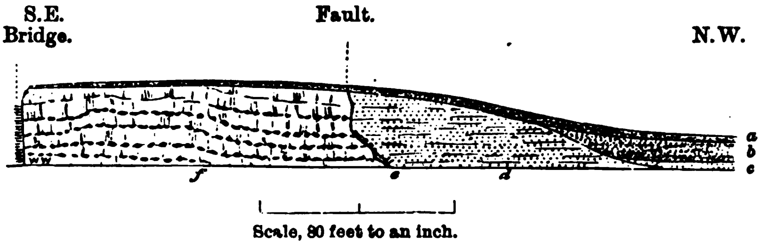

FIG. 49.—Cutting near St. John's Railway Station, near Lewisham. (W. Whitaker). (Scale, 80 feet to an inch.)

a = Soil. *b*, *c* = River Drift. *d* = Thanet Sand. *c* = Chalk.

The zone *M. coranguinum* is also exposed in a quarry about a mile south of Keston, where Mr. Dibley has obtained that species and its variety *latior*, with *Epiaster gibbus, Galerites albogalerus, Cyphosoma corollare, Cidaris sceptrifera* and other fossils.

At Lewisham (Loam Pit Hill) the chalk was formerly worked to a depth of 40 feet, and Mr. Whitaker remarks that there were eight layers of flints, the third from the top being a continuous seam (Op. cit., p. 154). The cutting on the North Kent line just north of St. John's Station passes through a faulted junction of the Chalk with the Thanet Beds (see Fig. 49), and Mr. Whitaker (*op. cit.*, p. 114) notes that the chalk has flints in layers, three of which are well marked.

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* Geology of London, Mem. Geol. Survey, 1889, p. 115.

List of Fossils from the Upper Chalk of West Kent.

This list has been drawn up from the following sources:—

First, the collections of the Geological Survey at Jermyn Street, and small collections made by Mr. Rhodes for the Survey at Strood and Frindsbury. These are indicated by figures.

Second, the lists of fossils from Lewisham and Charlton given by Mr. H. J. Johnston-Lavis in his paper on the "Geology of Lewisham," Proc. Geol. Assoc., Vol. iv. p. 528 (1876). These are indicated by the letter L.

Third, the lists published by Mr. G. E. Dibley, of Sydenham, including species collected by him from many localities in the west of Kent (see Proc. Geol. Assoc. Vol. xvi. p. 484.) These species, where their occurrence was not previously known to the Survey, are indicated by the letter D.

A few species added from records in the volumes of the Palæontographical Society are indicated by the letter P.

Bryozoa, Ostracoda, and Foraminifera are not included in this list, but those which have been recorded from the Upper Chalk of Kent will be found in the general list at the end of the volume.

The list from the *M. cortestudinarium* zone at Chatham is that of a collection made by Mr. Gamble, of New Brompton, and purchased from him by the Geological Survey. A few of the fossils in this series may possibly have come from the base of the *M. coranguinum* zone, but only a little of that zone is accessible in one of the two pits from which he obtained them (see p. 162).

—		Zone of M. cortestudinarium.			Zone of M. coranguinum.			Highest Beds.		
	Zone of H. planus. 1	Cuxton and Halling. 2	Borstal Fort, &c. 3	Chatham. 4	Stroud. 5	Charlton. 6	Lewisham. 7	Frindsbury 8	Gravesend and Northfleet. 9	Cliffe. 10
Pisces.										
Anomœodus cretaceus, *Ag.*	–	–	–	–	–	–	–	–	D	–
Beryx (? genus)	–	D	–	4	5	–	–	–	9	–
Ctenothrissa microcephalus, *Ag.*	–	–	–	–	5	–	–	–	–	–
Hoplopteryx lewesiensis, *Mant.*	–	–	–	–	–	–	–	–	–	–
Cestracion rugosus, *Ag.*	–	–	–	–	D	–	–	–	–	–
Cimolichthys lewesiensis, *Leidy*	–	D	–	–	–	–	–	–	9	–
Corax falcatus, *Ag.*	D	–	–	4	–	–	–	–	9	–
Dercetis elongatus, *Ag.*	–	D	–	–	–	–	–	–	–	–
Enchodus lewesiensis, *Mant.*	–	D	–	–	–	6	–	–	–	–
Lamna appendiculata, *Ag.*	1	–	–	4	–	6	7	–	9	D
„ macrorhiza, *Cope*	–	–	–	–	–	–	–	–	D	–
Macropoma Mantelli, *Ag.*	D	–	–	–	–	–	–	–	–	–
Notidanus microdon, *Ag.*	–	D	–	4	–	–	–	–	9	–
Oxyrhina Mantelli, *Ag.*	–	D	D	4	D	–	–	–	9	–
„ angustidens, *Reuss*	–	–	–	–	–	–	–	–	D	–
Protosphyræna ferox, *Leidy*	–	D	–	4	–	6	–	–	9	–
Ptychodus decurrens, *Ag.*	–	D	–	4	–	6	7	–	9	–
„ latissimus, *Ag.*	1	–	–	–	–	–	–	–	D	–
„ mammillaris, *Ag.*	1	D	–	4	–	–	–	–	–	–
„ var. altior, *Ag.*	–	–	–	4	–	–	–	–	–	–
„ polygyrus, *Ag.*	–	–	–	–	–	–	–	–	9	–
„ rugosus, *Ag.*	–	–	–	–	5	–	–	–	D	–
Scapanorhynchus subulatus, *Ag.*	–	–	–	–	–	–	–	–	D	–

		Zone of M. cortestudinarium.			Zone of M. coranguinum.			Highest Beds.		
	Zone of H. planus. 1	Cuxton and Halling. 2	Borstal Fort, &c 3	Chatham. 4	Stroud. 5	Charlton. 6	Lewisham. 7	Frindsbury. 8	Gravesend and Northfleet. 9	Cliffe. 10
Pisces.										
Scapanorhynchus gigas, *Ag.*	-	-	-	-	-	-	-	-	D	-
Cephalopoda.										
Ammonites [Hapl.] leptophyllus, *Sharpe*	-	-	-	-	-	-	-	-	9	-
Aptychus	-	-	-	-	-	-	-	-	D	-
Actinocamax granulatus, *Blainv.*	-	-	-	-	D	-	-	-	9	D
„ verus, *Miller*	-	-	-	-	-	-	-	-	-	D
„ westfalicus, *Schlüter*	-	-	-	-	-	-	-	-	D	D
Belemnitella lanceolata, *Schloth.*	-	-	-	-	-	L ?	L?	-	9	-
Gasteropoda.										
Hipponyx Dixoni, *Sow.*	-	-	-	4	-	-	-	-	-	-
Pleurotomaria perspectiva, *Mant.*	-	D	-	4	-	-	-	-	D	-
Solariella gemmata, *Sow.*	D	-	-	-	-	-	-	-	-	-
Lamellibranchiata.										
Anomia sp.	-	-	-	-	-	-	-	-	D	-
Inoceramus Brongniarti, *Sow.*	-	-	-	4	5	-	-	-	-	-
„ cordiformis, *Sow.*	-	-	-	-	-	-	-	-	9	-
„ Cuvieri, *Sow.*	D	D	3	-	-	-	-	-	-	-
„ digitatus, *Sow.*	-	-	-	-	-	-	-	-	9	-
„ involutus, *Sow.*	-	-	-	4	5	-	-	-	-	-
„ Lamarcki ? *Park.*	-	-	-	4	-	-	-	-	-	-
„ undulatus, *Sow.*	-	-	-	4	-	-	-	-	-	-
„ sp. 1	-	-	3	4	-	-	-	-	-	-
„ sp. 2	-	-	-	-	5	6	L	8	-	-
Lima granulata, *Nilss.*	-	-	-	-	-	-	-	-	-	-
„ granosa, *Sow.*	-	-	-	-	-	-	-	-	D	D
„ Hoperi, *Sow.*	-	D	3	4	D	6	7	-	9	-
„ leviuscula, *Sow.*	-	D	-	-	-	-	-	-	-	-
„ sp. (ribbed)	-	-	-	-	-	-	-	-	9	-
Ostrea acutirostris, *Nilss.*	-	-	-	4	6	-	-	8	9	-
„ curvirostris, *Nilss.*	-	-	-	-	D	-	-	-	-	-
„ normaniana, *d'Orb.*	1	D	3	4	D	-	-	-	9	D
„ semiplana, *Sow.*	-	-	3	4	-	D	-	-	9	-
„ sulcata, *Blum.* (=flabelliformis)	-	-	-	-	-	-	-	-	9	-
„ vesicularis, *Lam.*	-	2	3	4	-	L	-	-	9	D
Pecten cretosus, *Defr.* (=nitidus, *Mant.*)	-	-	-	-	D	L	L	-	9	D
„ sp.	-	-	-	-	-	-	-	-	D	-
„ (Neithea) quinquecostatus, *Sow.*	-	-	3	4	-	L	-	-	9	-
Pinna decussata, *Sow.*	-	-	-	-	-	-	-	-	D	-
Plicatula sigillina, *S. P. Woodw.*	-	-	3	4	5	-	-	-	-	-
„ Barroisi, *Peron*	D	-	-	-	-	-	-	-	-	-
Radiolites Mortoni, *Mant.*	-	-	-	-	-	-	-	-	9	-
Septifer lineatus, *Sow.*	1	2	-	-	-	-	-	-	9	-
Spondylus dutempleanus, *d'Orb.*	-	2	-	4	-	-	-	-	9	-
„ latus, *Sow.*	1	D	3	4	D	L	L	-	9	D
„ spinosus, *Sow.*	1	D	3	4	D	L	L	8	9	D
Teredo amphisbæna, *Goldf.*	-	-	-	-	-	-	-	-	D	-
Brachiopoda.										
Cistella Bronni, Hag. (=Argiope)	-	-	-	-	-	-	-	-	P	-
Crania egnabergensis, *Retz*	-	-	-	4	-	L	L	-	9	-
„ parisiensis, *Defr.*	-	-	3	4	-	-	-	-	9	-
Kingena lima, *Defr.*	-	-	-	-	-	D	-	-	9	-
Magas pumilus, *Sow.*	-	-	-	-	-	-	-	-	9	-
Rhynchonella Cuvieri, *d'Orb.*	1	2	D	-	-	-	-	-	-	-
„ limbata, *Schloth.*	-	-	-	4	5	-	-	-	-	-
„ plicatilis, *Sow.*	-	2	D	-	-	-	-	-	-	D
„ „ var. octoplicata, *Sow.*	1	-	-	4	-	L	L	-	9	D
„ reedensis, *Eth.*	1	2	-	4	5	-	-	-	9	D
„ sp.	-	-	-	-	-	D	-	-	-	-
Terebratula carnea, *Sow.*	1	2	3	4	5	L	L	-	9	-
„ semiglobosa, *Sow.*	1	2	3	4	5	L	L	-	9	D
Terebratulina gracilis, *Schloth.* var.	1	D	D	4	-	-	-	-	-	-
„ striata, *Wahl.*	1	-	-	4	-	D	-	-	9	-
Thecidium Wetherelli, *Morris*	-	-	-	-	-	-	-	-	-	-
Bryozoa.										
Many species (see General List).										

		Zone of M. cortestudinarium.			Zone of M. coranguinum			Highest Beds.		
	Zone of H. planus. 1	Cuxton and Halling. 2	Borstal Fort, &c. 3	Chatham. 4	Stroud. 5	Charlton. 6	Lewisham. 7	Frindsbury. 8	Gravesend and Northfleet. 9	Cliffe. 10
Annelida.										
Serpula ampullacea, *Sow.*	–	–	–	4	D	–	–	–	D	–
„ **carinata**, *Sow.*	–	–	–	4	–	–	–	–	–	–
„ **fluctuata**, *Sow.*	–	–	–	4	D	–	–	–	–	–
„ **granulata**, *Sow.*	–	–	–	4	5	–	–	–	–	–
„ **ilium**, *Sow.*	–	–	–	4	D	–	–	–	9	–
„ **macropus**, *Sow.*	–	–	–	4	D	–	–	–	–	–
„ **plana**, *Sow.*	–	–	–	–	D	–	–	–	D	–
„ **plexus**, *Sow.*	–	–	–	4	D	–	–	–	9	–
Terebella lewesiensis, *Davies*	–	–	–	4	–	–	–	–	–	–
Crustacea.										
Enoploclytia Leachi, *Mant.*	–	–	–	4	–	6	–	–	9	–
Pollicipes glaber, *Roem.*	–	–	–	–	–	–	–	–	9	–
„ unguis, *Sow.*	D	D	–	–	–	–	–	–	D	–
Scalpellum maximum, *Sow.*	–	–	–	–	–	–	–	–	9	–
Ostracoda (*see* General List).										
Echinodermata.										
Bourgueticrinus ellipticus, *Miller*	1	D	3	4	5	6	7	8	9	D
Calliderma latum, *Forbes*	–	–	–	–	5	–	–	–	D	–
Cidaris clavigera, *König*	D	–	3	4	5	6	–	–	9	–
„ hirudo, *Sorig.*	D	–	–	4	5	–	–	8	9	–
„ perornata, *Forbes*	–	–	–	4	–	D	–	–	9	–
„ sceptrifera, *Mant.*	–	–	–	4	5	D	–	8	9	–
„ serrifera, *Forbes.*	–	–	–	–	–	–	–	–	D	–
„ subvesiculosa, *d'Orb.*	–	–	–	4	–	6	–	–	9	–
Cyphosoma corollare, *Klein*	–	–	–	–	–	6	–	–	9	–
„ granulosum, *Goldf.*	–	–	–	4	5	–	–	–	9	–
„ Kœnigi, *Mant.*	–	–	3	–	D	6	7	–	9	D
„ magnificum, *Ag.*	–	–	–	4	–	–	–	–	–	–
„ radiatum, *Sorig.*	1	–	–	–	–	–	–	–	9	–
„ spatuliferum, *Forbes*	–	–	–	–	–	–	–	–	9	–
„ Wetherelli, *Forbes*	–	–	–	–	–	–	–	–	9	–
Echinocorys scutatus, *Leske*	1	2	3	4	5	6	7	8	9	D
Epiaster gibbus, *Lam.*	–	–	–	–	D	D	–	–	D	D
Galerites castanea ? *Brongn.*	–	–	–	–	–	–	–	–	9	–
„ albogalerus, *Leske*	–	?	3	4	5	6	L	8	9	D
„ subrotundus, *Mant.*	–	–	–	–	5	–	–	8	9	–
„ globulus, *Desor*	–	–	–	4	5	6	–	–	9	–
Holaster planus, *Mant.*	1	2	–	4	–	–	–	–	–	–
„ placenta, *Ag.*	–	–	–	4	–	–	–	–	D	–
Metopaster Bowerbanki, *Forbes*	–	2	–	–	–	–	–	–	P	–
„ cingulatus, *Sladen*	–	–	–	4	–	–	–	–	–	–
„ Mantelli, *Forbes*	–	–	–	–	–	–	–	–	D	–
„ Parkinsoni, *Forbes*	–	–	–	–	–	6	L	–	9	D
„ uncatus, *Forbes*	–	–	–	–	–	6	–	–	9	–
Micraster coranguinum, *Leske*	–	–	–	–	5	6	L	–	9	–
„ corbovis, *Forbes*	D	–	–	–	–	–	–	–	–	–
„ cortestudinarium, *Goldf.*	–	–	3	4	–	–	–	–	–	–
„ Leskei, *Desm.*	1	2	–	–	–	–	–	–	–	–
„ præcursor, *Rowe*	1	2	3	4	5	–	–	–	–	–
Mitraster Hunteri, *Forbes*	–	–	–	–	–	–	7	–	D	–
„ rugatus, *Forbes*	–	–	–	–	–	–	–	–	9	–
Nymphaster Coombei ? *Forbes*	–	–	–	–	–	–	–	–	D	–
Offaster pillula, *Lam.*	–	–	–	4?	–	L	–	–	–	–
Ophiura serrata, *Roemer*	–	–	–	–	–	–	–	–	9	–
Oreaster Boysi, *Forbes*	–	–	–	–	–	6	–	–	–	–
„ bulbiferus, *Forbes*	–	–	–	–	–	–	–	–	9	–
Pentacrinus Agassizi ? *Hag.*	1	D	–	–	–	–	–	–	–	–
Pentagonaster megaloplax, *Sladen*	–	–	–	4	–	D	–	–	9	–
Salenia granulosa, *Forbes*	–	–	3	4	–	6	–	–	–	–
Actinozoa.										
Axogaster cretacea, *Lonsd.*	D	–	–	4	–	–	–	–	–	–
Caryophyllia cylindracea, *Reuss*	–	–	3	4	–	6	–	–	9	–
Diblasus grevensis, *Lonsd.*	–	2	–	4	–	–	–	–	9	–
Epiphaxum auloporoides, *Lonsd.*	–	–	–	4	–	–	–	–	–	–
Onchotrochus serpentinus, *Dunc.*	–	–	–	4	5	P	–	–	–	–

		Zone of M. cortestudinarium.			Zone of M. coranguinum.			Highest Beds.		
	Zone of H. planus. 1	Cuxton and Halling. 2	Borstal Fort, &c. 3	Chatham. 4	Stroud. 5	Charlton. 6	Lewisham. 7	Frindsbury. 8	Gravesend and Northfleet. 9	Cliffe. 10
Parasmilia centralis, *Mant.*	1	D	3	4	D	D	–	–	9	–
" cylindrica, *E. & H.*	–	–	–	–	–	–	–	–	D	D
" granulata, *Dunc.*	–	–	–	–	–	–	–	–	D	–
" monilis, *Dunc.*	–	–	–	–	–	–	–	–	P	–
" serpentina, *E. & H.*	–	–	–	–	–	–	–	–	P	–
Spinopora Dixoni, *Lonsd.*	–	–	–	4	–	–	–	–	–	–
Spongida.										
Aulaxinia costata, *Hinde*	–	–	–	4	–	–	–	–	–	–
Callopegma ficoideum, *Hinde*	–	–	–	4	–	–	–	–	–	–
Cephalites Benettiæ, *Mant.*	–	–	–	4	–	–	–	–	–	–
Cliona cretacea, *Portl.*	–	–	–	4	–	6	–	–	9	–
Coscinopora infundibuliformis, *Goldf.*	–	–	–	4	–	–	–	–	D	–
" quincuncialis, *T. Smith*	–	–	–	4	–	–	–	–	–	–
Doryderma ramosum, *Mant.*	–	–	–	4	–	–	–	–	–	–
" Rœmeri ? *Hinde*	–	–	–	4	–	–	–	–	–	–
Elasmostoma scitulum, *Hinde*	–	–	–	–	–	6	–	–	–	–
Guettardia stellata, *Mich.*	–	–	–	4	–	–	–	–	–	–
Heterostinia obliqua, *Benett*	–	–	–	4	–	–	–	–	D	–
Pachinion scriptum, *Hinde*	–	–	–	4	–	–	–	–	–	–
Pharetrospongia Strahani, *Sollas*	–	–	–	4	D	6	–	–	9	–
Pholadocladia ramosa, *Hinde*	–	–	–	4	–	–	–	–	–	–
Plinthosella compacta ? *Hinde*	–	–	–	4	–	–	–	–	–	D
" squamosa, *Zittel*	–	–	–	4	–	–	–	–	D	–
Plocoscyphia convoluta, *T. Smith*	–	D	3	4	D	D	–	–	9	–
Porosphæra globularis, *Phil.*	1	D	–	–	D	D	–	8	D	D
" pileolus, *Lam.*	–	–	–	–	–	D	–	–	D	–
Siphonia Kœnigi, *Mant.*	–	–	–	4	–	6	–	–	–	–
Steletta inclusa, *Hinde*	–	–	–	4	–	–	–	–	–	–
Stichophyma tumidum, *Hinde*	–	–	–	4	–	–	–	–	–	–
" sp.	–	–	–	4	–	–	–	–	–	–
Thamnospongia sp.	–	–	–	4	–	–	–	–	–	–
Ventriculites angustatus ? *Roemer*	–	–	–	4	–	–	–	–	–	–
" alcyonoides, *Mant.*	–	–	–	–	–	–	–	–	D	–
" decurrens, *T. Smith*	D	–	–	–	–	–	–	–	–	–
" impressus, *T. Smith*	D	–	–	–	–	–	–	–	–	–
" infundibuliformis, *S. Woodw.*	–	–	–	4	–	–	–	–	–	–
" mammillaris, *T. Smith*	D	–	–	–	–	–	–	–	–	–
" radiatus, *Mant.*	–	–	–	4	D	–	–	–	D	–
" (several species)	–	–	3	–	–	–	–	–	–	–

CHAPTER XIII.

THE UPPER CHALK IN SURREY.

GENERAL REMARKS.

No systematic exploration of the Upper Chalk of Surrey has yet been made, notwithstanding its proximity to the Metropolis and the frequency of exposures in quarries and railway cuttings.

Mr. Caleb Evans made an excellent reconnaissance in 1870 along the line of railway then being made between Croydon and Oxted, dividing the Chalk into zones and giving a list of the fossils he had found in each.* He discussed the species of *Micraster* and revised his divisions in a later paper.†

More recently Mr. G. E. Dibley has published some notes on quarries along the same line of country, with lists of the fossils found.‡

A large portion of the Upper Chalk seems to have been eroded and destroyed throughout Surrey before the deposition of the lowest Eocenes. If it were not so, the thickness of chalk below the Surrey Eocenes would be much greater than it is; thus if we refer to the record of the deep boring at Streatham§ we find that, including the beds which are regarded as forming a passage from the Middle to the Upper Chalk, there are only 221¼ feet assignable to the Upper Chalk (*i.e.*, zones of *Hol. planus*, *M. cortestudinarium*, and *M. coranguinum*). As the corresponding beds near Dover are about 360 feet thick, and about 300 feet at Gravesend, it is not likely that any of the Margate chalk is present; moreover it is stated that below the highest 19 feet the chalk under Streatham has beds of flints "every 2 or 3 feet," such a frequency of flint layers agreeing with the character of the *M. coranguinum* zone rather than that of *Marsupites*.

Further to the north-west, however, the thickness of Upper Chalk below the Eocenes is greater, 300 feet at Richmond, and 337 feet at Winkfield, near Windsor, so that it is possible that the zone of *Marsupites* does come in below these places. It may also begin

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[*] "Sections of Chalk between Croydon and Oxtead." Geol. Assoc. (Published in Lewes, 1870).

[†] Proc. Geol. Assoc., Vol. v. No. 4, p. 149 (1877).

[‡] Proc. Geol. Assoc., Vol. xvi. p. 484.

[§] Geology of London, Vol. ii. p. 224, Mem. Geol. Survey (1889).

to emerge from beneath the Eocene boundary in the south-east of Surrey.

STRATIGRAPHICAL DETAILS.

Zone of Holaster planus.

Several of the largest quarries in the Chalk of Surrey expose sections which extend from the *Terebratulina* zone through that of *Holaster planus*. The first of these, as we proceed from east to west, is the well-known quarry near the Rose and Crown Inn, four miles south of Croydon; the section taken here by Mr. Hill in 1896 was as follows:—

		Ft.	*in.*
Soil	- - - - - - - - - - - - - -	1–2	0
Zone of *Holaster planus*: 40 feet.	Firm chalk with layers of flints (part of this inaccessible) - - - - - - -	20	0
	A marked layer of flint - - - - -	0	6
	Firm white chalk - - - - -	3	0
	A marked layer of large flints - - - -	0	9
	Firm white chalk, a little irregular in texture, hard lumps in places. *Holaster planus* - -	4	0
	A thin seam of marl - - - - - - -	0	2
	Rather rough hard lumpy chalk, crystalline lumps in a softer matrix, often showing the structure of sponges in iron stains - - -	1	6
	A marked layer of flints - - - - -	0	9
	Firm white chalk of even texture throughout -	3	0
	A marked layer of flints - - - -	0	9
	Rough lumpy chalk, the lumps in a soft mealy matrix. *Holaster planus* -	1	6
	Irregular lumpy chalk with rather large scattered flints, inclined to arrange themselves in layers; in one place a thin seam of tabular flint - -	4	0
Part of *Terebratulina* zone.	White lumpy chalk with scattered flints -	6	0
	A marked course of hard creamy nodules in softer matrix, nodules often iron stained, showing structure of sponges - - - - -	1	0
	Thin seam of marl, below which is a layer of smallish flints - - - - - -	0	2
	White chalk, somewhat lumpy, but not so markedly as that above; layer of small flints at top, and a few scattered throughout - -	3	6
	Smooth white soft chalk, *Spondylus spinosus* -	3	0
	A course of hard nodular chalk with iron stains showing the structure of sponges - - -	1	0
	Firm white smooth chalk - - - - -	2	0
	Seam of marl - - - - - - -	0	3
	White smooth chalk seamed or veined with greenish grey in the middle part, above which is an irregular layer of flints - - - -	8	6
	A marked layer of hard nodular or lumpy chalk, nodules as usual showing structure of sponges in iron stains - - -	1	6
	White chalk in massive courses, divided by thin marl seams - - -	+50	0
		115	1

The cutting between the Merstham tunnel and Coulsdon station on the London, Brighton & South Coast Railway appears to traverse the zone of *Hol. planus*, for Mr. W. M. Holmes records *H. planus*, *Micraster Leskei* and *Terebratula carnea* from the heaps of chalk thrown out of this cutting. With them were many hollow flints containing a mealy substance from which he obtained a large number of *Radiolaria* in better preservation than any previously recorded from the Chalk of this country. He has described and figured 41 species belonging to 20 genera.*

One of the most interesting sections of the chalk at this horizon occurs in the cuttings of the railway from Croydon to Epsom, just north and south of Chipstead Station. The continuity of the section is broken by a roadway and by excavations at the station, but probably only a small thickness of chalk is thus missed. The cutting just north of the station gates, as seen by Mr. Hill in the autumn of 1899, gave the following section:—

		Ft.	*in.*
	Soil and rubble - - - - - - - - - -	3	0
Zone of *M. cortestudinarium.*	Broken chalk (*Echinocorys scutatus*) - -	3	0
	Firm rough chalk veined with grey - - -	4	0
	Rough lumpy chalk rather uneven in texture, hard lumps in a softer matrix stained brown in places, some flints, *Echinocorys scutatus*, *Micraster cortestudinarium* - - - -	2	0
	Softer firm white chalk with flints - - -	2	6
	Hard rough lumpy chalk, the upper surface fairly well marked, upper part creamy white with rusty stains, but passing down into softer and whiter chalk, *Micraster* - - - -	2	6
	Softer chalk, white, but texture uneven; harder in some places than in others; flints - - -	6	0
		23	0

An excavation in the station at a lower horizon than the above showed softish white chalk with flints, containing *Micraster præcursor* and *M. cortestudinarium.*

At the top of the cutting, just south of Chipstead Station, was white softish chalk, probably the continuation of that seen in the station. The dip of the beds in this cutting is very slight, and it is necessary to walk half a mile along the line south of the station to obtain the following sequence:—

		Ft.	*in.*
Zone of *Holaster planus.*	Soil and rubble - - - - - - -	2	6
	Soft white chalk with flints, *Echinocorys scutatus*, *Micraster* sp., *Terebratula semiglobosa* -	8	6
	Chalk consisting of hard lumps in a softer matrix	5	0
	Hard rough lumpy chalk, neither top nor bottom well defined, but passing into the chalk above and below - - - - - - - - -	1	4
	A rather massive bed of rough lumpy chalk. *Micraster* sp. - - - - - - -	2	0

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* On Radiolaria from the Upper Chalk at Coulsdon, Quart. Journ. Geol. Soc., Vol. lvi. p. 694, Plates xxxvii. and xxxviii. (1900).

		Ft.	in.
Zone of *Holaster planus.*	A well defined bed of hard rough nodular rock, the nodules at the top sometimes green coated; many fossils (see below) - - - -	2	0
	Hard chalk, smoother than the above, veined with greenish grey; some fossils - -	5	6
	Smooth white soft chalk in two courses, *Micraster præcursor*, *Holaster planus*, *Cyphosoma radiatum* and *Cardiaster* sp. - - - - - - -	3	0
	Massive white chalk with a few large black flints seen for	3	0
		32	10

In the soft white chalk at the base of this section were three well marked layers of tabular flint, and in one place a fourth layer was visible. These layers were about a foot to 15 inches apart, but to the northward approached gradually to each other. At the same time the bed of hard veiny chalk immediately above the soft white decreased rapidly in thickness from 5½ feet to 3½ feet.

This veiny chalk and the rough nodular rock above yielded the following species. *Micraster præcursor*, *M. cortestudinarium*, *Echinocorys gibbus*, *Inoceramus Cuvieri*, *Spondylus spinosus*, *Terebratula semiglobosa*, and *Rhynchonella* sp.

The facies of the assemblage of Micrasters from the upper beds of this section is that of the highest part of the zone of *H. planus* at Dover, while the occurrence of this species associated with Micrasters in the soft white chalk below supports this view. But the sudden change from hard rocky chalk to the soft white chalk at the base of the cutting is very striking, and strongly reminds one of the ordinary succession at the horizon of the Chalk Rock in Hertfordshire or Cambridgeshire. Micrasters are more abundant in this cutting than in any other locality along the North Downs.

The following notes are also by Mr. Hill:—

The Echo quarry, about a mile to the south-east of Guildford, presents another good section at this horizon. It is an old quarry, long since disused, but there yet remains a perpendicular face at least 100 feet high, which, though inaccessible, gives a view of the succession of chalk through the zone of *Holaster planus* to the Upper Chalk. From the view obtained here it would seem that the "chalk with flints" comes in as described with the zone of *Holaster planus*, and at what we should take as about the summit of this zone there appears a space of some 30 feet (estimated, for this part is not accessible), in which there are few if any flints, and above this layers of flint are seen to set in again regularly.

It is possible to examine some 50 feet of the face on the western side of the quarry, and taken generally, the section there agrees with that at the Rose and Crown quarry.

Another section occurs about 5 miles West of Guildford, at Monkshatch. This must have been once a large quarry; it is now converted into pleasure grounds, surrounding the residence of — Hitchens, Esq. The section taken in 1896 was as follows :—

		Ft.	*in.*
Zone of *Holaster planus* 42 feet.	Soil and rubble	3	0
	White chalk of irregular texture, hard lumps in softer matrix, arranged in discontinuous beds with layers of softer chalk between, flints in layers and also scattered. *H. planus* (quite at the top), *Micraster Leskei*, *M. prœcursor*	22	0
	Firm white chalk	1	6
	Irregular bed of flints	1	0
	Massive bed of firm white chalk in two courses	3	6
	Layer of flints	0	9
	Massively bedded firm white chalk in two courses separated by a thin marl seam. *Hol. Planus*	6	3
	Layer of flints	0	6
	Course of firm white chalk	3	0
	Layer of flints	0	6
	White chalk of irregular texture, with scattered flints, most numerous in the lower part	3	6
	A well marked layer of large scattered flints	1	6
Part of the *Terebratulina* zone.	Firm white chalk	4	0
	Course of hard crystalline lumps, iron stained, the whole course very firm and hard	1	0
	White soft chalk	1	0
	Another course of very hard nodular or lumpy chalk	1	0
	The section is broken here by a talus heap, and there is a small fault, but the gap cannot be great.		
	Soft white chalk	6	0
	Layer of marl	0	6
	Softish white chalk, in which there are three layers of flint and a few scattered nodules	16	0
		76	0

The measurements in this section are given as taken without regard to the dip of the beds, which is about 15° N.

The lower part of the zone of *Holaster planus* is again exposed at the Victory quarry, near Farnham, but the section does not extend far in the zone.

Zone of Micraster cortestudinarium.

To this zone belong the Upper Kenley Beds of Mr. C. Evans.

The only quarry examined by Mr. Hill in Surrey where the chalk was undoubtedly referable to the zone of *Micraster*

cortestudinarium is that close to Coulsdon Station. The section taken in 1896 was as follows :—

		Ft.	in.
	Soil, etc.	1	0
Zone of *Micr. corang.*	Soft white chalk with layers of flints at intervals of 4 or 5 feet	21	0
	Soft white chalk without flints	12	0
	Layer of flints	0	6
Zone of *Micraster cortestudinarium*, 44 feet seen.	Very firm, scarcely hard chalk, veined with green grey, with layers of flint and many scattered	25	0
	Softer chalk with but few flints. *Micraster*.	6	0
	A course of hard creamy nodules in soft mealy matrix, nodules are sometimes iron stained, scattered flints. This course is called "Bull rough" by the quarrymen. *Micraster* sp.	4	0
	Softer white chalk. *Micraster* sp.	5	0
	A line of large flints	0	6
	Soft white chalk seen for	4	0
		80	6

Although we could not identify any of the Micrasters as *M. cortestudinarium*, they belong to the *præcursor* group, and have the characters of those found in that zone near Dover.

There is also a quarry at Purley Junction which appears to be opened at about the same horizon and to show parts of the zones of *M. cortestudinarium* and *M. coranguinum*. Mr. Hill found *M. præcursor* and Mr. Dibley obtained *M. cortestudinarium*, *Holaster placenta* and *Spondylus spinosus* from the lower beds, while the higher part is believed to belong to the zone of *M. coranguinum*, but without definite evidence.

The exposure of this zone in the railway cutting north of Chipstead Station has been described above, and in the next cutting, a quarter of a mile north of the station, there is a course about 6 inches thick of hard yellowish compact chalk, which yielded *M. præcursor* of a low zonal type; this bed may mark the top of the zone of *M. cortestudinarium*.

Zone of Micraster coranguinum.

It is impossible to determine from Mr. C. Evans' descriptions how much of the chalk described by him should be referred to the zone of *M. coranguinum*. In his later paper (1877) he refers the whole of what he had previously called the Purley Beds and the Upper Kenley Beds to the zone of *M. cortestudinarium*, but as these two groups would have from his account a thickness of 170 feet, and as he allows 80 feet for the underlying zone of *Holaster planus*, it is evident that if his estimates are accepted much of the 170 feet must belong to the zone of *M. coranguinum*. The probability is that the greater part of the Purley Beds are referable to this zone.

In describing the cuttings near Purley, Mr. Evans mentions that cutting No. 4 is through the northern slope of Riddlesdown, and in the appendix he gives the following section at the northern entrance of the tunnel:—

	Ft.	*in.*
Chalk and flints (obscure).[1]		
Two layers of flints with chalk between - - -	?1	0
Chalk in two beds - - - - - - - - - - -	3	8
Band of large flint nodules.		
Chalk - - - - - - - - - - - - - - -	2	6
Flint nodules and chalk - - - - - - - -	1	0
Chalk with *Micraster* and occasional flints - - -	1	2
Irregular flint nodules.		
Chalk in several beds, with two layers of flints - -	7 or 8	0

In this cutting the beds dip to the north, in the next cutting (No. 3) they have a slight but perceptible dip to the south, which can be traced by a band of large flints, probably the same band as that noted in the section above given. The same beds seem to occur in the cutting to the north (No. 2), where they recover their northerly dip, for he says :—" The most interesting deposits in this cutting are two beds of chalk, separated by a band of flint nodules, and having a band of large flint nodules above. These two beds contain many specimens of *Micraster coranguinum* together with other fossils," and he afterwards speaks of this as the " Micraster band."[2]

In cutting No. 1, by the road from Purley to Sanderstead, higher beds come in, dipping gently to the north, and from the details given by Mr. Evans the following seems to have been the succession :—

		Ft.	*in.*
Chalk and rubble - - - - - - -	about	2	0
Chalk with two layers of flints - - - - -	„	5	0
Layer of tabular flint.			
Chalk with two layers of flint - - - - -	„	7	0
Band of marl - - - - - - - - - -		0	3
Chalk with layer of flints below - - - - -	„	1	4
Chalk and flints (sloped and smoothed) - -	„	7	6
	About	23	0

In his later paper (p. 151) he remarks that " the Purley sections are more than 100 feet below the junction of the two formations," *i.e.*, Chalk and Eocene; and to this highest part of the Chalk he gives the name of the " Croydon Beds." He further observes that *Echinoconus conicus* (*Galerites albogalerus*) is very common in this highest chalk, occurring in that position at Lewisham, Chiselhurst, Keston, and Croydon.

A quarry opposite the Royal Oak at Haling, in the parish of Croydon,* is notable as being that in which a large boulder of granite was found in 1857. This boulder was described by Mr. Godwin-Austen,* from whose account it appears to have been a large, rounded, water-worn, and "boldly egg-shaped" mass of granitic rock; the width of one end seems to have been about 12 inches, but its length is unknown, as it was broken up before measurements were taken. With this large boulder there were also a number of smaller blocks of some kind of greenstone, described as consisting of "augite with tabular double crystals of felspar; the largest of these, from the portions which remain, must have been of considerable size, weighing as much as 20 or 25 pounds, but in common with all the other specimens of the same rock it was much decomposed, ... the smaller pebbles were wholly decomposed and readily fell to pieces, forming a sharp sand." There was also a compact mass of sand, examination of which showed it to be "a fine water-worn beach-sand, derived from the waste of a coast-line of some crystalline rocks."

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*Mr. Whitaker informs me that this pit has been erroneously stated to be at Purley. There is another large pit at Purley Station.

Mr. W. Hill visited this quarry in 1897, and furnishes the following notes of the chalk therein exposed. About 80 feet of rather firm white chalk are seen here; the flints are not exactly in layers, but in courses of scattered nodules, and many small flints are scattered through the intervening chalk. There is a seam of continuous flint near the top, two somewhat feeble seams lower down, and a fourth near the bottom, in the south-west corner of the quarry. Characteristic specimens of *Micraster coranguinum* were found in the face of chalk associated with *Echinocorys scutatus*. At the kilns at the south-west corner the following beds are seen:—

	Ft.	*in.*
Soil and rubbish - - - - - - - - - - -	1	0
Firm whitish chalk - . - - - - - - - -	0	4
Cream-coloured chalk broken into irregular fragments -	0	9
Softer white blocky chalk - - - - - - ·	1	0
Hard yellowish compact chalk with well-marked upper surface - - - - - - - - - - - -	0	6
Firm blocky white chalk with flints - - - - · -	3	0
	6	7

Mr. E. T. Newton subsequently found in the chalk which forms the floor of this pit a *Micraster præcursor* of a type like those in the *M. cortestudinarium* zone.

Mr. Hill thinks the hard yellow chalk may mark the top of the *M. cortestudinarium* zone, as it resembles the bed exposed in the railway cutting a quarter of a mile north of Chipstead Station.

Zone of Marsupites.

In the eastern part of Surrey this zone is either concealed beneath the Eocene, or more probably was removed from the summit of a low anticlinal flexure formed and eroded before the deposition of the Tertiaries.

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* See Quart. Journ. Geol. Soc, Vol. xiv. p. 252 (1858).

In the western part of the county, however, it is probable that the zone of *Marsupites* comes in again from beneath the Eocene boundary, for, as we shall presently see, it is unquestionably present in the north of Hampshire. Dr. Barrois thought he recognised it near Guildford in 1876, and refers to it as follows[*] :—"The north side of the Hogs Back . . . . consists of a soft chalk with few flints, but with some tabular flint; these are the mineralogical characters of the zone of *Marsupites*; moreover, it contains *Offaster corculum*, *Echinoconus conicus*, and *Micraster coranguinum* . . . . Below this zone the chalk contains much more frequent layers of flint nodules, and this belongs to the zone of *Micraster coranguinum.*"

Fossils from the Upper Chalk of Surrey.

The following is a list of such fossils as have hitherto been obtained from the Upper Chalk of Surrey. In the first column are entered those recorded (1) by Mr. C. Evans from his Lower Kenley Beds, (2) those found by Mr. Hill. In the second column are fossils from the Upper Kenley and Riddlesdown Beds of Mr. Evans (*a*), those found by Mr. Hill and Mr. Dibley (*b*), and those obtained from a new railway cutting near Coulsdon by Mr. W. M. Holmes, of Croydon (*c*). The third column includes (4) species recorded by Mr. Evans and Mr. Holmes from the Purley Beds, (5) fossils found by Mr. G. E. Dibley at Haling and South Croydon, (6) a few obtained by Mr. Holmes from a pit near Warlingham Court. Our thanks are due to Mr. Dibley and Mr. Holmes for putting their lists at our disposal:—

——	Zone of Hol. planus.		Zone of M. cortestudinarium.		Zone of M. coranguinum.		
Vertebrata.							
Anomœodus cretaceus, *Ag.*	–	–	b	–	–	5	–
Cimolichthys lewesiensis, *Leidy.*	–	–	–	–	–	5	–
Cladocyclus lewesiensis, *Ag.*	–	–	–	–	–	5	–
Corax falcatus, *Ag.*	–	–	b	–	4	5	–
Enchodus sp.	–	–	b	–	–	5	–
Ichthyodectes sp.	–	–	–	–	–	5	–
Lamna appendiculata, *Ag.*	–	–	b	–	–	5	–
Notidanus microdon	–	–	–	–	–	5	–
Oxyrhina Mantelli, *Ag.*	–	–	a	–	4	5	–
Pachyrhizodus Gardneri, *Mason*	–	–	–	–	–	5	–
Ptychodus latissimus, *Ag.*	–	–	–	–	–		–
,, mammillaris, *Ag.*	–	2	–	–	–	–	–
,, rugosus, *Ag.*	–	–	–	c	–	5	–
Scapanorhynchus subulatus, *Ag.*	–	–	–	–	–	5	–

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[*] Recherches sur le Terrain Crétacé Sup., 1876, p. 130.

——	Zone of Hol. planus.	Zone of M. cortestudinarium.	Zone of M. coranguinum.
Mollusca.			
Pleurotomaria perspectiva, *Mant.*	– –	b –	4 – –
Inoceramus Cuvieri, *Sow.*	1 2	– –	4 – –
„ involutus, *Sow.*	– –	– –	– 5 –
„ undulatus, *Mant.*	– –	– –	4 – –
„ sp. (like striatus)	– –	a –	– – –
Lima Hoperi, *Sow.*	– –	– c	4 5 –
Ostrea normaniana, *d'Orb.*	– –	– –	4 – 6
„ semiplana, *Sow.*	– –	– –	4 – –
„ vesicularis, *Lam.*	– –	a –	– – –
Pecten concentricus, *Woodw.*	– –	– –	– 5 –
„ cretosus, *Defr.* (= nitidus, *Mant.*)	– –	– –	4 5 –
„ britannicus, *Woods*	– –	– –	– 5 –
„ (Neithea) quinquecostatus, *Sow.*	– –	a –	– 5 –
Spondylus latus, *Sow*	– –	a –	– 5 –
„ spinosus, *Sow.*	– 2	a, b, c	4 5 –
Teredo amphisbæna, *Goldf.*	– –	– c.	– – –
Brachiopoda.			
Crania egnabergensis, *Retz.*	– –	a –	4 – –
„ parisiensis, *Defr.*	– –	a –	– – –
Rhynchonella Cuvieri, *d'Orb.*	1 –	– c	– – –
„ limbata, *Schloth.*	– –	a	4 – 6
„ plicatilis, *Sow.*	1 2	– c	4 – –
„ reedensis ? *Eth.*	– –	a –	
Terebratula carnea, *Sow.*	1 –	a, b c	4 5 –
„ semiglobosa, *Sow.*	1 2	a, c	4 5 –
Terebratulina gracilis, *Schloth.* var.	1 –	b –	– – –
„ striata, *Wahl.*	1 –	a, b	4 – –
Thecidium Wetherelli. *Morris*	– –	a –	– – –
Bryozoa.			
Alecto gracilis, *M. Edw.*	– –	a –	4 – –
„ ramosa, *Roemer*	– –	a –	– – –
Desmepora semicylindrica, *Roemer*	– –	a –	– – –
Diastopora Sowerbyi, *Lonsd.*	– –	a –	4 – –
Entalophora sp.	– –	– –	– 5
Homœosolen sp.	– –	a –	4 – –
Truncatula alternata, *d'Orb.*	– –	c –	– – –
Crustacea.			
Enoploclytia Leachi, *Mant.*	– –	– –	– 5 –
Scalpellum arcuatum, *Darw.*	– –	– –	– 5 –
Annelida.			
Serpula plexus, *Sow*	– –	a –	4 – –
Terebella lewesiensis, *Davies*	– –	– –	4 – –
Echinodermata.			
Bourgueticrinus ellipticus, *Miller.*	– –	a, c	– 5 –
Cidaris clavigera, *König.*	– –	– c	4 – –

—	Zone of Hol. planus.	Zone of M. cortestudinarium.	Zone of M. coranguinum.
Cidaris sceptrifera, *Mant.*	– 2	– c	4 5 6
Cyphosoma Kœnigi, *Mant.*	– –	– –	– 5 –
„ corollare, *Klein*	– –	– –	– 5 –
„ radiatum, *Sorig.*	1 2	– c	– – –
Echinocorys scutatus, *Leske*	1 2	a, b, c	4 5 –
Epiaster gibbus *Lam.*	– –	– –	– 5 –
Galerites albogalerus, *Leske*	– –	– –	– 5 –
Holaster planus, *Mant.*	1 2	a	– – –
„ placenta, *Ag.*	– –	b, c	4 5 –
Micraster coranguinum, *Leske*	– –	– –	4 5 6
„ corbovis, *Forbes* (? Leskei)	1 –	c	– – –
„ cortestudinarium, *Goldf.*	– 2	a, b, c	– – –
„ Leskei ? *Desm.*	1 –	– –	– – –
„ præcursor, *Rowe*	– 2	b, c	– – –
Offaster pillula, *Lam.*	– –	– –	4 ? – –
Actinozoa.			
Parasmilia centralis, *Mant.*	– –	a	4 5 –
Synhelia sharpeana, *E. and H.*	– –	– –	– 5 –
Spongida.			
Camerospongia campanulata, *T. Smith*	1 –	– –	– – –
Plinthosella squamosa, *Zitt.*	– –	– –	– 5 –
Plocoscyphia convoluta, *T. Smith*	1 –	b –	– 5 –
„ vagans, *Hinde*	– –	– –	4 – –
Porosphæra globularis, *Phil.*	– –	– –	4 5 –
„ pileolus, *Lam.*	– –	b –	– 5 –
Siphonia Kœnigi, *Mant.*	– –	– –	4 – –
Ventriculites alcyonoides, *T. Smith*	– –	a, c	– – –
„ decurrens, *T. Smith*	– –	– –	4 – 6
„ mammillaris, *T. Smith*	1 –	– –	– – –
„ radiatus, *Mant.*	– –	c	– 5 –
Radiolaria (in flints)	– –	c	– – –

CHAPTER XIV.

THE UPPER CHALK IN NORTH HAMPSHIRE.

GENERAL REMARKS.

That part of Hampshire to which the following account relates is wholly comprised within the Basingstoke and Andover sheets of the new series of Ordnance Maps (Sheets 283, 284). Our knowledge of the zones in this district is primarily due to Professor Barrois,* but Mr. E. Westlake made some subsequent exploration of the country,† and Mr. Ch. Griffiths and Mr. R. M. Brydone have more recently explored much of the district, and have collected diligently from all the principal exposures near Andover, Whitchurch, Micheldever, and Basingstoke.

The Chalk Rock (zone of *Holaster planus*) crops out round the uplifts of Kingsclere and Shalbourne and is probably succeeded by a thin zone of *M. cortestudinarium*, though at present we have no certain evidence of its existence.

The zone of *Micraster coranguinum* occupies large parts of the surface area of this district, because it is brought up round the uplifts of Kingsclere and Shalbourne, and the *Marsupites* zone forms a narrow band for some distance along the Northern border, just below the Eocene boundary. To the southward, also, there are synclinals by which the *Marsupites* zone, with more or less of the *Act. quadratus* zone, are brought in. South of Whitchurch and Overton the zone of *M. coranguinum* makes its appearance again, not only in the lower ground, but on the high ground north of Micheldever.

It is evident that a careful zonal study of this district would bring out some interesting facts respecting the flexures of the Chalk and the subsidiary system of synclines and anticlines which exists in this area, which is really a prolongation of the compound Wealden uplift.

Nothing is definitely known with regard to the local thickness of the several zones into which the Upper Chalk is divided, but

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*Recherches sur le Terrain Crétacé supérieur, p. 38 *et seq.*, 1876.

† Tabular Index to the Fossils cited by Dr. Ch. Barrois (1888).

it is probable that their relative thicknesses are nearly the same as in the central part of Hampshire, described in Chapter V.

STRATIGRAPHICAL DETAILS.

1. The Chalk Rock Beds.

These beds must be regarded as a condensed equivalent of the zone of *Holaster planus*.

I am informed by Mr. Bennett that there are several exposures of these beds along the cincture of the Kingsclere inlier. On the northern side of the vale he found them exposed in a quarry three-eighths of a mile south-west of Kingsclere Church, in another quarry less than a mile N.N.E. of Burghclere, and a still better section in the railway-cutting west of the latter (see Fig. . The beds in each case are dipping northward at angles of from 20° to 28°, and the succession at each place is the following :—

	Feet.
White chalk with flints.	
Hard compact yellowish limestone	2 to 3
Greyish-white nodular chalk	12 or 13
Hard chalk-rock, with a layer of green-coated nodules at top and another below	6 or 7

On the south side of the vale the rock is well shown in the first cutting on the railway north of Litchfield Station, where the beds are dipping to the south at about 4°. Of this section Mr. Whitaker furnishes the following account :—

		Feet.
	White chalk with flints.	
Chalk Rock Beds.	Very hard cream-coloured chalk, with a few pale greenish nodules	3
	Hard white bedded chalk with two thin discontinuous seams of flint	11
	Hard chalk with a layer of flints at the top	1
	Hard chalk-rock, jointed, with a layer of green-coated nodules at the top, where it is fossiliferous	2
	Hard chalk	4
	Hard chalk-rock like the above, but not so marked, passing down into hard chalk	? 1
		22

From the sections above mentioned Mr. Rhodes was able to obtain a fair number of fossils. (See list at the end of this chapter.)

In the Bourne Valley a good section through these beds is found in a quarry at the foot of Stoke Hill one and a half miles south-east of Hurstbourne Tarrant (see Fig. 50). This section was carefully measured by Mr. E. Westlake, and his account was published in Steven's "History of St. Mary Bourne" (1863).

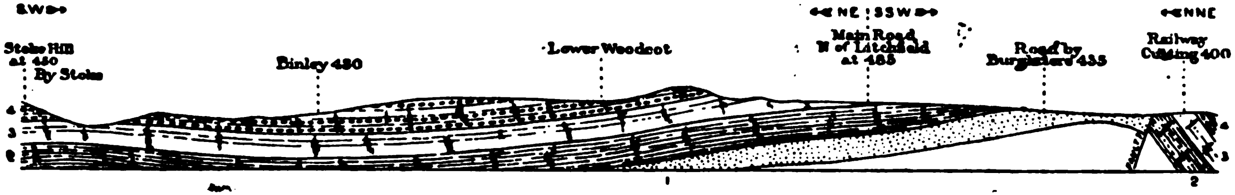

FIG. 50.—Section from Stoke Hill to Burghclere (Kingsclere anticline).

Horizontal Scale, one inch to a mile. Vertical Scale, 1,400 feet to an inch.

4. Upper Chalk.
3. Middle Chalk.
2. Lower Chalk.
1. Selbornian.

Somewhat abbreviated, it is as follows, but the bracketing of the beds into zones is my own:—

		Ft.	*in.*
	Soft chalk with a seam of flint 9 inches from bottom	3	9
Chalk Rock Beds, 13 feet 7 inches.	*Upper rock-bed*—very hard chalk, slightly ochreous, much broken, but defined at the top	2	0
	Softish white chalk without flints	7	9
	Layer of rusty flints, forming top of *Sponge-bed*—hard nodular chalk with black specks and many decayed irregular flints full of spicules; in places the chalk contains cavities	1	0
	Lower rock-bed. Two courses of very hard chalk, the upper surfaces of which are irregular and well defined. The top 3 or 4 inches of each course contains green-coated nodules, pyrites, and many fossils (see list on page 191).	2	10
Terebratulina Zone.	Nodular chalk, consisting of hard lumps in a softer matrix with wavy streaks of grey marl	2	8
	Layer of green coated nodules and pyrites	0	2
	Nodular chalk, like that above	6	6
	Soft grey marl	0	4
	Compact greyish chalk, lumpy but less so than the beds above and breaking into larger blocks; a few scattered flints. *Spondylus spinosusis* common	12	0

Mr. Westlake divided the beds above the marl band into a zone of *Holaster planus* and a zone of *Micraster breviporus*. When he wrote it was natural to place the nodular chalk above this band in the former zone, but we have already explained (Vol. II. p. 410) why Mr. Hill and I take a different view.

It might be thought that the two-inch layer of green-coated nodules should be regarded as part of the Chalk Rock, but such nodules occur at many horizons in the Chalk, and the mere occurrence of such nodules a few feet below a bed of Chalk Rock is no good argument for including such a layer in the same zone. Mr. Westlake found no fossils in this thin layer of nodules, and the special fauna of the Chalk Rock, with its Cephalopods and Gasteropods, does not come in till the lower rock-bed is reached.

It has been mentioned in Chapter VII. that a similar layer occurs in the Isle of Wight, and has actually been called Chalk Rock, but that we regard it as lying in the *Terebratulina* zone, and altogether below the true representative of the Chalk Rock in that island.

Mr. Westlake gave a list of the various fossils which he found in each bed, but the upper rock-bed only yielded an imperfect *Micraster*. These fossils are listed on p. 191 in their respective zones under the letter s, but we mention here that the fossils found in the nodular chalk at the top of the *Terebratulina* zone were: *Holaster planus, Micraster Leskei, Rhynchonella plicatilis. Terebratula semiglobosa, Inoceramus cf. cuneiformis,* and *Natica* sp.

2. Zone of Micraster coranguinum.

This zone probably occupies a considerable area to the east and west of Basingstoke. Professor Barrois supposed the town to be on the zone of *Marsupites* (op. cit. p. 39), but he was unable to find many fossils. Messrs. Griffith and Brydone, however, have devoted some time to collecting from the railway cutting of the Great Western Railway east of Basingstoke Station, and consider it to be in the zone of *M. coranguinum*, the occurrence of that fossil with *Galerites albogalerus* and *Actinocamax verus* and the absence of any plates of *Marsupites* leading them to that conclusion. There is another exposure of the same chalk in the siding east of the junction with the South Western Railway.

It might be thought that the occurrence of *Actinocamax verus* was suggestive of the *Marsupites* zone, since at Margate and elsewhere that fossil is associated with *Marsupites*. Mr. Griffith, however, informs me that this does not seem to be the case in Hampshire; that they have never found it in any section where plates of *Marsupites* occur, while it is not uncommon in the chalk which appears to be referable to the zone of *M. coranguinum*.

On the northern side of the Vale of Kingsclere the outcrop of this zone must form a very narrow band, for on the maps of the Geological Survey the whole space occupied by the Upper Chalk is in places not more than 350 yards across, and the beds are indicated as dipping northward at angles of from 25° to 40°. It is probably exposed in the third railway cutting north of Burghclere, but no one has yet obtained any information respecting the zonal succession in this cutting.

On the south side of the Vale the zone of *M. coranguinum* occupies the ground for some distance to the south and east of Litchfield. Dr. Barrois describes it as chalk with banded flints and some cavernous flints, but with few fossils except fragments of *Inoceramus;* he notes it as visible at Cold Henley and Larks Barrow Hill, about two miles south of Litchfield, and again to the south-east at Woolding Farm and Travellers' Rest.

He considered Whitchurch and Hurstbourne Priors to be on the Marsupite chalk, but Mr. E. Westlake inclines to the opinion that the beds there seen by Professor Barrois belong to the zone of *M. coranguinum*, and the same is the case with regard to the chalk round Overton to the eastward.

The New Barn cutting on the railway between Whitchurch and Hurstbourne stations is in the *M. coranguinum* zone, and Dr. J. Stevens obtained many fossils here when the cutting was being made (see list on p. 191). Professor Barrois recognised the same zone at Chapmans ford, where banded flints occur in layers at distances of 1½ to 3 feet apart. The large quarry near Hurstbourne Priors shows soft chalk in horizontal beds, with black flints in layers about the same distance apart, and here Professor

Barrois obtained many fossils. Of this Mr. Westlake writes that it is known locally as the Bee House pit, and that "evidence as to the horizon of this pit has been furnished by the recent cuttings on the Hurstbourne and Fullerton branch, about a mile west of the pit, and 100 feet above it, which contain *M. coranguinum* and *E. conicus*" (=*Galerites albogalerus*), and *Actinocamax verus* is recorded by Professor Barrois.

To the east of Whitchurch is another large quarry at the Whiting works, described by Professor Barrois as containing layers of large cavernous flints at distances of 3 to 6 feet; in the upper parts are banded flints, and 3 feet from the top a yellowish layer with a marked upper surface. This pit is clearly in the *M. coranguinum* zone, and Mr. Westlake says the cutting at the South Western Railway station, 100 feet above the pit, has furnished numerous *Micraster coranguinum* and *Galerites albogalerus*. Of the flints in this cutting Mr. Charles Griffith, of Winchester, writes that they are very numerous both in layers and as scattered nodules, that inside they are sometimes black, but more often grey or brown, and frequently mottled with moderately thick crusts. There is a layer of very large flat flints at the top near the bridge, which seems to show an easterly dip.

Of the quarry mentioned by Prof. Barrois at "Norrington," Mr. Westlake writes:—"By this name, taken from the old one-inch map, is intended the pit at Southington corn-mill, half a mile west of Overton. The railway cutting at Overton Station, 100 feet above this pit, contains numerous *M. coranguinum* and *E. conicus*. I have failed to find *E. conicus* in the Southington pit, and I refer it to the same horizon as the whiting pit at Whitchurch," where it is very rare—namely, to the lower part of the *M. coranguinum* zone.

On the great railway cutting north of Micheldever Station, Mr. Charles Griffith kindly furnishes me with the following notes:—"The chalk is solid, moderately soft, with very many flints; these are of all shapes and sizes, in layers and scattered, skins very thin to fairly thick, interior generally black but sometimes grey. Echinoderms are remarkably abundant (*Galerites*, *Echinocorys*, *Micraster*, *Cidaris*, *Cyphosoma*, etc.; see list). *Actinocamax verus* is not uncommon here, but I refer the chalk to the upper part of the *M. coranguinum* zone." In this opinion Mr. Westlake concurs.

Professor Barrois states (*op. cit.*, p. 49) that Andover is also probably on this zone, though some of the higher ground to the east of the town may consist of the *Marsupites* chalk.

2. Zone of Marsupites.

The extent of this zone in the northern part of Hampshire is at present quite uncertain, because no one has yet explored the region with a view to separating it from the overlying zone of *Actinocamax quadratus*. When Professor Barrois made his researches he included in his zone of *Marsupites* the greater portion of the chalk which we now refer to that of *Act. quadratus*, and consequently we cannot be guided by his references to the zone except where he actually records plates of *Marsupites*, and this is only in one instance (Harewood, near Andover).

Mr. Griffith however informs me that he is right in referring the large quarry near Chinham, 1¼ miles north of Basingstoke, to the zone of *Marsupites*, for plates of that fossil have since been found there in abundance. Professor Barrois describes the chalk seen in this quarry as soft and white, containing a few rounded flints, which are either white or yellow outside, and occur as scattered nodules, not in layers, though there are some thin flint seams (*lits tabulaires*). Messrs. Griffith and Brydone have collected many fossils here, and the list will be found on p. 191.

It seems probable that near Basingstoke the continuity of the *Marsupites* zone is broken by a gentle uplift connected with that of the Kingsclere district, and that, as already stated, most of the chalk near Basingstoke, and that exposed between Overton and Whitchurch, belongs to the zone of *M. coranguinum*.

West of Whitchurch, however, higher beds appear to come in again, for, on the highest ground occupied by Harewood Forest, Professor Barrois found plates of *Marsupites* between Hurstbourne and Andover, the exact position of which he does not state, but mentions that the flints are rather large, banded, and yellow outside.

There are also two quarries east of Andover which, according to Mr. Griffith, may be referred either to the zone of *Marsupites* or to that of *Act. quadratus*. One of these is by the old road east of the town, but has not yielded many fossils; the other is a large pit on the road to Micheldever, and has yielded a number of small fossils, *Offaster pillula* being not uncommon at the upper end of the pit, but *Marsupites* have not yet been found at either place.

This zone in all probability occupies some considerable area to the north of Andover, beneath the Dole Wood district, for Mr. Westlake states that at Frenches Copse, south of Hurstbourne Tarrant, the Eocene rests on the zone of *Marsupites*.*

It may also be exposed at the northern end of the third cutting on the railway north of Burghclere Station, for Mr. Rhodes (collecting for Mr. Bennett) obtained a plate of *Marsupites* there.

4. Zone of Actinocamax quadratus.

This zone appears to come in at certain places along the central part of the Chalk area between the anticlines of Winchester and Kingsclere. Probably it only occurs in the form of outliers in the central parts of the deeper synclinal troughs. For the following notes I am indebted to Mr. Charles Griffith :—"A disused chalk-pit at Weston, by the side of the railway, three miles south of Micheldever Station, has yielded many specimens of *Offaster pillula* and many *Bryozoa*, and as in our experience *Offaster pillula* only occurs above the chalk in which Marsupite plates have been found, I am disposed to assign this pit to the lower part of the *Act. quadratus* zone, and to place it on the same horizon as the chalk exposed at the top of the large quarry east of Andover.

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* In the History of St. Mary Bourne, by E. Stevens.

"Two specimens of *Actinocamax granulatus* were found in 1898 in a pit two miles north of Sutton Scotney, on the east side of the road to Whitchurch, and *Offaster pillula* was found in a pit on the south side of Sutton village. *Act. granulatus* has also been found in one of the quarries east of Andover."—(C.G.)

It is possible also that some part of this zone may come in to the north-west of Andover, near Hatherton and Tangley, on the borders of Wiltshire, for in all probability there is a synclinal axis running from south-east to north-west, parallel to the anticlinal axis of the Bourne Valley (St. Mary Bourne to Vernham's Dean). Part of this tract west of Ibthorpe is 300 feet or more above the outcrop of the Chalk Rock in that village, a height which with the contributing dip would probably suffice to bring in the *Act. quadratus* zone.

LIST OF FOSSILS FROM THE UPPER CHALK OF NORTH HAMPSHIRE.

The following list of fossils from the Upper Chalk of North Hampshire has been compiled from several sources.

That of the Chalk Rock and associated beds is partly from collections made by Mr. J. Rhodes for the Geological Survey, partly from a list sent me by Mr. C. Griffith, and from lists given by Mr. Westlake in Dr. Stevens' History of St. Mary Bourne; those obtained from Litchfield, Kingsclere, etc., are indicated by the letter *r*, and those from Stoke by the letter *s*.

The fauna of the *M. coranguinum* zone is compiled from the following sources; (*n*) that given by Mr. Westlake from the New Barn cutting, Whitchurch; (*b*) from Professor Barrois' list of the Bee House quarry, Whitchurch, supplemented by the results of Mr. Griffith's collecting at the same place; and, lastly (*m*) from a list, kindly furnished by Mr. Griffith, of fossils found by him and Mr. Brydone in the cutting at Micheldever.

The species recorded from the higher zones are entirely due to the diligent collecting of Messrs. Griffith and Brydone, who have most generously placed their lists at my disposal. The letters in these columns signify the following localities: *a* Andover, *c* Chinham, *o* Odiham, *t* Sutton Scotney, *w* Weston.

—	Zones of H. planus and M. cortestudinarium.	Zone of Micr. coranguinum.	Zone of Marsupites.	Zone of Act. quadratus.
Pisces.				
Cimolichthys lewesiensis, *Leidy* - - -	—	m	a	—
Corax falcatus, *Ag.* - - - - - - -	—	n b m	—	—
Enchodus lewesiensis, *Mant.* - - - -	—	b	a	—
Lamna appendiculata, *Ag.* - - - - -	—	n b m	—	—
„ semiplicata ? *Ag.* - - - - -	—	n	—	—
Oxyrhina crassidens, *Ag.* - - - - -	—	n m	—	—
„ Mantelli, *Ag.* - - - - -	s	n m	—	—
Ptychodus latissimus, *Ag.* - - - -	—	n m	—	—
„ mammillaris, *Ag.* - - - -	—	n	—	—
„ polygyrus, *Ag.* - - - -	—	n m	—	—
Cephalopoda.				
Ammonites [Pachydiscus] peramplus, *Mant.* -	r s	—	—	—
„ sp. - - - - - - - -	—	b	—	—
Baculites bohemicus, *Fritsch* - - - -	r s	—	—	—
Heteroceras sp. - - - - - -	r	—	—	—
Scaphites Geinitzi, *d'Orb.* - - - - -	r	—	—	—
Actinocamax granulatus, *Blainv.* - - -	—	—	—	a t
„ verus, *Miller* - - - -	—	b m	—	—
Nautilus sublævigatus, *d'Orb.* - - - -	r s	—	—	—
Gasteropoda.				
Aporrhais Mantelli, *Gard.* - - - -	r	—	—	—
Avellana, cf. Humboldti, *Muller* - -	r	—	—	—
Cerithium Saundersi, *Woods* - - - -	r	—	—	—
Natica vulgaris? *Reuss* - - - - -	r	—	—	—
Pleurotomaria perspectiva, *Mant.* - - -	r s	m	—	—
Trochus Schlüteri, *Woods* - - - - -	r	—	—	—
Turbo gemmatus, *Sow.* - - - - -	s	—	—	—
„ sp. - - - - - - - - -	s	—	—	—
Lamellibranchiata.				
Avicula sp. - - - - - - - -	—	—	a	—
Inoceramus sp. - - - - - - - -	—	n b m	a c o	w
„ sp. like latus, *d'Orb.* - - -	r s	—	—	—
Lima Hoperi, *Sow.* - - - - - -	—	n m	c	—
„ læviuscula, *Sow.* - - - - - -	—	—	—	w
„ pectinata, *d'Orb.* - - - - -	r	b	a	w
Ostrea acutirostris, *Nilss.* - - - -	—	—	a	—
. curvirostris, *Nilss.* - - - -	—	n b	a	w
„ canaliculata, *Sow.* (= lateralis) - -	s	n b	a c	w
„ hippopodium, *Nilss.* - - - -	s	n b	a	—
„ normaniana, *d'Orb.* - - - -	—	b	—	—
„ semiplana, *Sow.* - - - - -	—	b	—	—
„ vesicularis, *Lam.* - - - - -	—	n b	a o	—
„ ungulata, *Schloth.* - - - - -	—	—	—	w
„ wegmanniana, *d'Orb.* - - - - -	—	n b m	a o	w
Pecten cretosus, *Defr.* (=nitidus, *Mant.*) -	—	n b m	a	w
„ (Neithea) sex-costatus, *Sow.* - -	—	n	o	w
„ (Neithea) Dutemplei, *d'Orb.* - -	—	b m	—	—
Plicatula sigillina, *Woodw.* - - - -	r	n b m	a	—
Septifer lineatus, *Sow.* - - - - -	r s	b	—	—
Spondylus dutempleanus, *d'Orb.* - - -	—	b	a	w
„ latus, *Sow.* - - - - -	r	n b m	a c o	w
„ spinosus, *Sow* . - - - -	r s	n b m	o	w
Trapezium trapezoidalis, *Roem.* - - -	r	—	—	—
Brachiopoda.				
Crania egnabergensis, *Retz.* - - - -	—	m		—
„ parisiensis, *Defr.* - - - -	—	n	a	—
Rhynchonella Cuvieri, *d'Orb.* - - - -	r	—	—	—
„ limbata, *Schloth.* - - - -	—	b	—	—
„ plicatilis, *Sow.* - - - -	r s	n b m	a	w
„ reedensis, *Eth.* - - - -	r s	n b	a c o	w
Terebratula carnea, *Sow.* - - - -	s	m	—	—
„ obesa, *Sow.* - - - - -	—	m	—	—
„ semiglobosa, *Sow.* - - - -	r s	n m	—	—
„ sexradiata, *Desh.* - - - -	—	n b m	a	—
Terebratulina gracilis, *Schloth.* (? Rowei) -	—	—	a	w
„ striata, *Wahl.* - - - -	—	n b m	a c o	w
Thecidium Wetherelli, *Morris* - - -	—	n b m	a c	w
Bryozoa.				
Ceriocava ramulosa, *Mich.* - - . -	—	n	a	w —
Lunulites cretaceus, *Defr.* - - - -	—	b	—	—

—	Zones of H. planus and M. cortestudinarium.	Zone of Micr. coranguinum.	Zone of Marsupites.	Zone of Act. quadratus.
Crustacea.				
Pollicipes glaber, *Roemer*	—	—	a	—
Scalpellum semiporcatum, *Darwin*	—	—	—	w
Annelida.				
Serpula ampullacea, *Sow.*	—	n b	a o	—
„ fluctuata, *Sow.*	r	n	a	—
„ granulata, *Sow.*	—	—	a	—
„ plexus, *Sow.*	s	n m	a o	—
„ turbinella, *Sow.*	—	n b	—	w
Echinodermata.				
Bourgueticrinus ellipticus, *Miller*	—	n b m	a c o	w
„ sp. nov.	—	n b	—	—
Cidaris clavigera, *König*	—	n b m	—	w
„ hirudo, *Sorig.*	—	n b m	a c o	—
„ perornata, *Forbes*	—	n m	—	—
„ sceptrifera, *Mant.*	—	n m	o	—
„ serrifera, *Forbes*	—	m	—	—
„ subvesiculosa, *d'Orb.*	—	n	—	w
Cyphosoma Kœnigi, *Mant.*	—	n m	—	w
„ radiatum, *Sorig.* (= simplex)	—	n m	—	—
„ corollare, *Klein*	—	m	—	—
„ sp.	—	b m	a c o	—
Echinocorys scutatus, *Leske*	r s	n b m	a	w
„ „ var. pyramidata	—	—	o	—
Epiaster gibbus, *Lam.*	—	n m	—	—
Galerites albogalerus, *Leske*	—	n b m	o	—
„ subrotundus, *Mant.*	—	n m	—	—
Holaster planus, *Mant.*	r	—	—	—
„ placenta, *Ag.*	r s	—	—	—
Infulaster excentricus, *Forbes*	—	n b	—	—
Marsupites testudinarius, *Schloth*	—	—	a c	—
Metopaster Parkinsoni, *Forbes*	—	n b	—	—
„ uncatus, *Forbes*	—	—	—	—
„ sp.	—	n	c	—
Micraster coranguinum, *Leske*	—	n b m	c o	—
„ cortestudinarium, *Goldf.*	r	m	—	—
„ Leskei, *Desm.*	r s	—	—	—
„ præcursor, *Rowe.*	r	—	—	—
Offaster pillula, *Lam.*	—	—	a	t w
Ophiura serrata, *Roemer*	—	n	—	—
Oreaster bulbiferus, *Forbes*	—	n m	—	—
„ pistilliferus, *Forbes*	—	n	—	—
Pentacrinus sp.	—	n	—	—
Salenia granulosa, *Forbes*	—	n	—	—
Uintacrinus westfalicus, *Schlüt.*	—	—	o	—
Actinozoa.				
Axogaster cretacea, *Lonsd.*	—	n b	c	w
Caryophyllia cylindracea, *Reuss*	r	—	—	—
Epiphaxum auloporoides, *Lonsd.*	—	n m	—	—
Parasmilia centralis, *Mant.*	s	n m	a c	—
Spongida.				
Cephalites paradoxus, *T. Smith*	—	n	—	—
Cliona cretacea, *Portl.*	—	—	a	—
Porosphæra globularis, *Phil.*	r s	n b m	a c o	w
„ pileolus, *Lam.*	—	n b m	a c o	w
„ Woodwardi, *Carter*	—	n b m	a c o	w
Ventriculites cribrosus? *Phil.*	s	—	—	—
„ impressus, *T. Smith*	r	n	—	—
„ mammillaris, *T. Smith*	r	—	—	—
„ radiatus, *Mant.*	r	—	—	—

CHAPTER XV.

THE UPPER CHALK IN NORTH WILTSHIRE AND WEST BERKSHIRE.

GENERAL REMARKS.

We shall regard North Wilts as including the whole of the Vale of Pewsey, as well as all that part of the county which lies north of a line drawn east and west from Westbury to Ludgershall.

The boundary line formed by the outcrop of the Chalk Rock has been mapped chiefly by Mr. F. J. Bennett, and many exposures have been noted by him and some by myself, for the rock-beds have been quarried for many years to obtain road metal. The Chalk Rock was well known to the Rev. S. Townsend at the beginning of last century, and is noticed by him in the following passage*:—" In descending the hills from Everley to the Vale of Pewsey a second bed [of chalk] appears, hard, rubbly, and tinctured with green, improper for the uses to which the former is applied, and fit only for the highways."

On the south side of the Vale of Pewsey no great thickness of Upper Chalk comes in, probably less than 200 feet, and not reaching higher than the middle of the zone of *Micraster coranguinum*. North and north-east of the Vale a greater thickness comes in, and near Marlborough there is probably quite 300 feet of Upper Chalk, but as nothing higher than the *M. coranguinum* zone comes in below the Eocene, we must suppose that the higher zones have been overlapped by the Eocene in passing from east to west.

It will be convenient to describe in this chapter what is known of the Upper Chalk in that part of Berkshire which adjoins Wiltshire, that which lies to the north of the river Kennet and west of the Thames valley. This district includes the greater part of the chalk area of Berkshire, but with the exception of the basement beds (Chalk Rock) little is known about it.

The higher portions of the Chalk are largely covered by " clay with flints " and remaniè Eocene material, but chalk is exposed on the slopes of all the valleys which drain south into the Kennet and its tributary the Lambourn. The beds belong to the zones of *Micraster cortestudinarium* and *M. coranguinum*, and it is improbable that any higher zone emerges from beneath the Eocene in this region.

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*The Character of Moses established for Veracity, &c., 4 to p. 98, 1813: a work which contains much more geological information than might be expected from its title.

The sections in the valley of the Thames will be more conveniently considered in the following chapter with those in the adjoining parts of Oxon and Bucks.

A.—North Wiltshire.

In 1901 Mr. E. Meyrick and the members of the Marlborough College Natural History Society made a systematic search for fossils in the various quarries and exposures within reach of Marlborough, and the specimens found were sent to me for identification. It is entirely due to the search conducted by Mr. Meyrick that I am able to give the list of fossils that will be found on page 200, for it had previously been supposed that the Chalk Rock was not very productive in North Wiltshire, nor had the higher zones been definitely recognised.

The Chalk Rock Beds.

The zone of *Holaster planus* is probably represented in Wiltshire by the Chalk Rock which usually consists of several courses of compact cream-coloured limestone, each course terminating upward in a layer of green-coated nodules. These nodules are lumps of chalk which have been rolled and slightly phosphatised on the sea-floor.

There are many old quarries in the Chalk Rock on the summit of the Downs east of Westbury, but most of the sections are shallow, and do not expose more than 3 or 4 feet of the rocky beds.

A deeper exposure was found by my colleague, Mr. Bennett, in a quarry on Stoke Hill, south of Earlstoke, where the following beds were seen :—

	Feet.
White chalk with flints - - - - - - - -	2½
Layer of green-coated nodules - - - - - - -	½
Hard nodular chalk without green nodules - - - -	6
Hard nodular chalk with four layers of green-coated nodules	3
Hard cream-coloured chalk rock - - - - seen for	1½

In another pit about two miles south-east of Earlstoke the hard cream-coloured rock is exposed for 3 feet without being bottomed, so the Chalk Rock beds are more than 12 feet thick in this district.

On Redhorn Hill, south-east of Urchfont, part of the rock is exposed in quarries on each side of the road, and the beds seen were :—

	Feet.
Hard white compact limestone with glauconite grains and two layers of green-coated nodules - - - -	3½
Very hard compact limestone without green grains - -	1
Talus below.	

Mr. Bennett has traced the outcrop of the Chalk along the southern border of the Vale of Pewsey, but reports that there are no good exposures of it.

On the hill west of Enford (Avon Valley) a well was sunk in 1890 by Mr. J. W. Titt, of Warminster, who has given me the following particulars of the beds passed through:—

	Feet.
Chalk with many flints - - - - - - - - - -	104
Hard rocky chalk (sample of Chalk rock sent) - - -	18
Solid white chalk - - - - - - - - - - -	72
	194

At the eastern end of the vale the outcrop of the Chalk Rock curves round the village of Tidcombe, and runs along the west side of Botley Hill, passing thence into the Vale of Shalbourn; but the space on the ridge east of Marton, from which the rock beds have been removed, is not more than a quarter of a mile in length.

From this ridge the outcrop is continuous westward along the northern side of the Vale of Pewsey, the northerly dip increasing till between Durley and Hewish there are dips of from 20° to 30°. It is exposed in the cutting on the new railway N.W. of Savernake Station.

A good section of the rock was recorded by Mr. Whitaker in 1861 near the top of the hill on the road N.N.E. of Oare; he describes it as showing over 11 feet of hard-rocky chalk with six layers of green-coated nodules, each of the latter being 2 or 3 inches thick.* Mr. Bennett examined this section in 1889, and sends me the following account of the exposure then visible:—

	Feet.
Chalk with flints - - - - - - - - - - -	2
Massive white chalk with a few flints scattered through it -	10
Hard cream-coloured chalk-rock with four layers of green-coated nodules; base not seen - - - - - - -	7

West of St. Ann's Hill the Chalk Rock beds occur only in outliers, and many shallow quarries have been opened to get stone for road material. One of these, on Bishops Cannings Down, as seen in 1888, was about 7 feet deep, showing 3 feet of rubbly nodular chalk overlying 4 feet of hard compact rock, with layers of green-coated nodules.

On Morgans Hill, still further west, there are several small quarries, and one at the north-east end showed about 6 feet of rock, the central bed about 2 feet thick, and consisting of hard lumps embedded in soft greyish-white chalk with many fossils and fragments

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*Quart. Journ. Geol. Soc., Vol. xvii. p. 167.

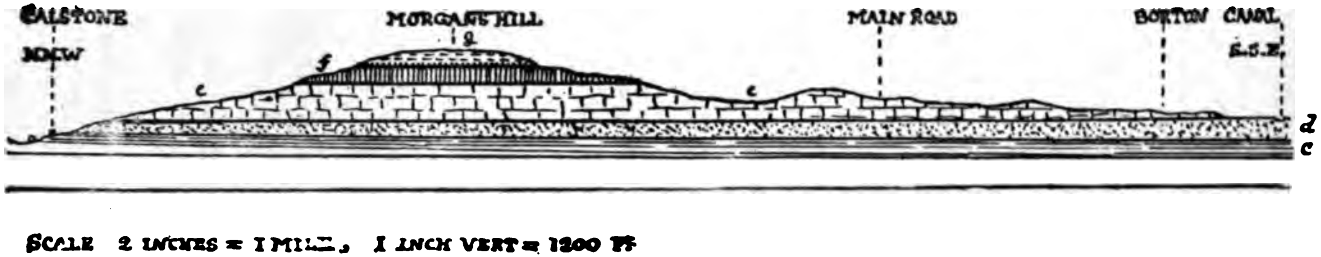

FIG. 51.—Section through Morgan's Hill, near Devizes. From Proc. Geol. Assoc.; Vol. xii. p 258.

g. Middle Chalk.
f. Upper Chalk.
e. Lower Chalk.
d. Greensand. } Selbornian.
c. Gault. } Selbornian.

of brown phosphate. The beds above and below were of the ordinary compact kind, with layers of green-coated nodules.

On Oldbury Hill, a pit north-west of Witch Plantation shows 2 feet of rubbly chalk resting on hard compact limestone with green-coated nodules. A similar section is exposed in another pit to the eastward (see p. 198).

These facts suggest that the complete succession in this district would be as follows:—

	Feet.
Compact limestone beds with layers of green-coated nodules; some fossils	5
Soft chalk with hard lumps, many fossils	2
Beds of compact limestone with layers of green-coated nodules; some fossils	5
	12

The following notes on exposures of the Chalk Rock near Marlborough are by my colleague, Mr. F. J. Bennett.

West of Marlborough the Chalk Rock runs along Overton Hill, where it is exposed in a small pit. A better exposure occurs in the Valley of Stones, north of Pickledean Barn, where about 3 feet of the rock is seen, and from this exposure the members of the Marlborough College Natural History Society have obtained many fossils. There is another quarry east of Down Barn in the same valley, exposing about 9 feet of rock, with four layers of green-coated nodules.

In Marlborough the rock is exposed in a pit in the field north west of the "Marquis of Ailesbury's Arms"; it was seen in the foundation trenches for the new buildings at Marlborough College, about 6 feet from the surface, and the outcrop runs eastward to Mildenhall.

North of Marlborough the best section is in a quarry west of Ogbourn Maisey, and is as follows:—

		Feet.
Soft chalk with flints		2
Chalk Rock—hard yellowish limestone in six courses with a layer of green-coated nodules at the top of each course		8
Middle Chalk.	Hard nodular whitish chalk	5
	Soft blocky chalk	3
		18

Here also the rock-beds contain many fossils. There are also quarries in the Chalk Rock on the brow of Hackpen Hill to the N.W.

Zone of Micraster cortestudinarium.

The beds of this zone do not appear to be frequently exposed in North Wilts, but the chalk which directly overlies the Chalk Rock probably belongs to it.

To this zone may be referred the white chalk with scattered flints which overlies the Chalk Rock on Oare Hill (*see* page 195), and Mr. Meyrick informs me that *Micraster præcursor* and *Echinocorys scutatus* have been obtained from this chalk.

Similar chalk is exposed in a quarry at the south-eastern end of Oldbury Castle Hill, and of this Mr. Meyrick sends me the following particulars; "The depth of chalk exposed is not more than 6 feet and it consists of whitish chalk, some parts of which are very hard; flints of rather small size are scattered throughout irregularly, and there is one well marked layer about 2 feet from the surface. *Echinocorys scutatus*, *Micraster præcursor*, *Cyphosoma radiatum* and a few other fossils were found."

What appears to be the downward continuation of this chalk and its junction with the Chalk Rock is shown in another pit half a mile north of the last. The section here, as communicated by Mr. Meyrick, is as follows:—

	Feet.
Rough chalk with scattered flints like that above described, *Micraster præcursor*, *Echinocorys scutatus*, and *Ventriculites impressus* - - - - - - - - - -	3½
Chalk Rock, very hard and full of large green-coated nodules; many fossils including *Crioceras ellipticum* and *Trochus Schlüteri* - - - - - - seen for	2½

Another pit on the same hill at the south-east corner of the old camp appears to be in the beds which overlie the Chalk Rock. The section (as seen by me in 1888) was—

	Feet.
Soft white chalk with a layer of large white-coated flints at the base - - - - - - - - - - - -	3
Hard rubbly rock with some fossils, but without any green-coated nodules - - - - - - - - seen for	6

The first cutting on the railway north of Marlborough passes through chalk with many layers of flints, but no further information respecting it has come into my hands, except that the beds dip southward, and probably include parts of both the zones of *M. coranguinum* and *M. cortestudinarium*.

The well at Marlborough Station reached Chalk Rock at a depth of about 150 feet, and the well at the Waterworks is 143½ feet deep, entirely through Upper Chalk, according to information furnished by Mr. Fairbank, the engineer, to Mr. F. J. Bennett.

There is another well at Messrs. Long and Barry's brewery, of which the following account has been given:—*

	Feet.
Old well, dug - - - - - - - - - - - -	28
Bored through soft chalk without flints - - - -	44
Chalk with 4 layers of flints - - - - - - - -	31
Hard chalk - - - - - - - - - - - - -	6
Mixture of chalk and flint - - - - - - - - -	8
Chalk with flint at the bottom - - - - - - -	6
Hard chalk - - - - - - - - - - - -	6
Chalk with flints at 135 feet and 140 feet - - - -	11
Chalk and fragments of shells - - - - - -	4
Chalk and flints - - - - - - - - - - -	6
	150

It is stated "The Chalk Rock was apparently reached at a depth of 106 feet, but the chalk was so crushed that this is uncertain."

3. Zone of Micraster coranguinum.

The best exposure of this zone near Marlborough is in the deep cutting at the northern entrance to the tunnel on the Midland and South Western Junction Railway south of the town. For the following note of this section I am indebted to Mr. E. Meyrick :—

White chalk, without flints - - -	about 15 feet
Layer of continuous tabular flint - - -	3 to 4 inches
White chalk, without flints - - -	about 15 feet
White chalk, with three layers of rather distant flints	„ 10 feet
Layer of continuous tabular flint - - -	„ 2 inches
White chalk with two layers of flints - - -	„ 10 feet
	About 50 feet

No fossils could be found in the chalk, but the upper flint-layer contains fragments of a large flat *Inoceramus*, some small sponges (*Siphonia Kœnigi*) and a Ventriculite.

The quarry on the west side of the Salisbury Road, south-east of Marlborough, seems to belong to this zone and has yielded *Micraster coranguinum* and *Cidaris perornata.* From anothor quarry near Cadley, about two miles south-east of Marlborough, Mr. Bennett obtained a portion of the Asteroid *Metopaster Mantelli.*

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* Rep. Marlborough Coll. Nat. Hist. Soc., No. 36, p. 132 (1888).

LIST OF FOSSILS FROM THE UPPER CHALK OF NORTH WILTS.

	Zone of Holaster planus.					Z. of M. cortestudinarium.	Z. of M. coranguinum.
	Morgans Hill. a	Oldbury Hill. b	Pickledean Barn. c	Ogbourn Maisey. d	Hackpen Hill. e	2	3
Pisces.							
Corax falcatus, *Ag.* (loc. uncertain)	–	–	–	–	–	–	–
Ptychodus sp.	–	–	–	d	–	–	–
Cephalopoda.							
Ammonites [Prionocyclus] Neptuni, *Gein.*	–	–	c	–	–	–	–
, [Pachydiscus] peramplus, *Mant.*	–	–	–	d	–	–	–
,, [Prionotropis] Woolgari, *Mant.*	–	–	–	d	–	–	–
Baculites bohemicus, *Fritsch*	–	–	–	d	–	–	–
Crioceras ellipticum, *Mant.*	–	b	–	–	–	–	–
Scaphites Geinitzi, *d'Orb.*	–	–	c	–	–	–	–
Nautilus sublævigatus, *d'Orb.*	–	–	c	d	–	–	–
Gasteropoda.							
Pleurotomaria perspectiva, *Mant.*	–	b	c	d	–	–	–
Solariella gemmata, *Sow.* (Turbo)	–	–	–	d	–	–	–
Trochus Schlüteri, *Woods*	–	b	–	–	–	–	–
Turbo Geinitzi, *Woods*	–	–	c	d	–	–	–
Lamellibranchiata.							
Cyprina quadrata, *Sow.*	a	–	–	–	–	–	–
Inoceramus Cuvieri, *Sow.*	?	b	c	d	–	2	–
,, striatus, *Sow.*	a	–	c	–	–	–	–
,, sp (large)	–	–	–	–	–	–	3
Pecten Nilssoni, *Goldf.*	–	–	–	d	–	–	–
,, (Neithea) 5-costata? *Sow.*	–	–	–	d	–	–	–
Spondylus spinosus, *Sow.*	a	–	c	d	e	2	–
Brachiopoda.							
Rhynchonella reedensis, *Eth.*	–	–	–	d	–	2	–
,, plicatilis, *Sow.*	–	–	–	d	–	–	–
,, ,, var. octoplicata, *Sow.*	a	b	–	–	–	–	–
Terebratula biplicata, *Sow.*	–	–	–	–	–	2	–
,, semiglobosa, *Sow.*	a	–	c	d	e	2	3
,, carnea, *Sow.*	a	b	c	d	e	–	–
Terebratulina gracilis, var lata, *Eth.*	–	–	–	d	–	–	–
Crustacea.							
Palæga Carteri, *H. Woodw.*	–	–	–	d	e	–	–
Echinodermata.							
Cidaris perforata, *Forbes.*	–	–	–	–	–	–	3
Cyphosoma radiatum, *Sorig.*	–	–	–	–	–	2	–
Echinocorys scutatus, *Leske*	–	–	c	–	e	2	3
Holaster planus, *Mant.*	–	–	–	d	–	–	–
Metopaster Mantelli, *Forbes*	–	–	–	–	–	–	3
Micraster Leskei, *Desm.*	–	–	c ?	d	e	–	–
,, præcursor, *Rowe*	–	–	–	–	–	2	–
,, coranguinum, *Leske*	–	–	–	–	–	–	3
Actinozoa.							
Parasmilia centralis, *Mant.*	–	–	–	d	e	2	–
Spongida.							
Camerospongia campanulata, *T. Smith*	–	b	–	–	–	–	–
Coscinopora quincuncialis, *T. Smith*	–	–	–	d	e	–	–
Doryderma ramosum, *Mant.*	–	–	–	–	–	2	–
Heterostinia obliqua, *Benett*	–	–	–	–	–	2	–
Phymaplectia cribrata, *Hinde*	–	–	–	–	–	2	–
,, spinosa, *Hinde*	–	–	–	–	–	2	–
Plinthosella nodosa, *Hinde*	–	–	–	–	–	2	–
Ragadinia compressa, *Hinde*	–	–	–	–	–	2	–
,, sulcata, *Hinde*	–	–	–	–	–	2	–
Siphonia Königi, *Mant.*	–	–	–	–	–	–	3
Thamnospongia glabra, *Hinde*	–	–	–	–	–	2	–
Thecosiphonia nobilis, *Roemer*	–	–	–	–	–	2	–
Ventriculites decurrens, *T. Smith*	a	–	–	–	–	–	–
,, impressus, *T. Smith*	–	–	–	d	e	2	–
,, mammillaris, *T. Smith*	–	–	–	d	–	–	–
,, radiatus? *Mant.*	–	b	–	–	–	–	–

2.—West Berkshire.

The Chalk Rock Beds.

White Horse Hill is the northern termination of a ridge which carries two long outliers of Upper Chalk based upon Chalk Rock, the southernmost extending nearly to Lambourn.

Mr. F. J. Bennett found the Chalk Rock exposed in several of the roadways near Lambourn and informs me that one of the best sections was on the road leading up hill from Bockhampton, about a mile south-east of Lambourn; this shows the base of the rock, and the beds seen are:—

	Feet.
Hard cream coloured chalk with a layer of green-coated nodules at the top	6
Hard nodular white chalk	3

From Lambourn the outcrop of the rock runs northward to Sparsholt Down, and thence eastward along the summit of the main escarpment. Along this tract the rock-beds have been quarried at frequent intervals for road metal, so that many sections of these beds have been exposed from time to time, but they are mostly shallow quarries following one or more of the hard beds, and none of them exposed so much as 20 feet of chalk.

One of the best sections open in 1887 was in a quarry on the north-east side of Sparsholt Down, and as soft white chalk was exposed at the top it would seem that the rock-beds here worked are the very highest of the group. The succession seen by me was as follows:—

	Feet.
Soft-white chalk, breaking into thin platy pieces with nodules of light grey flint at the base	3
Hard compact white limestone *without* green grains; large green-coated nodules in the upper 6 inches	1½
Hard nodular greyish chalk	3
Greyish lumpy or nodular chalk with three layers of green nodules	3½
Hard yellowish limestone with green nodules and some glauconite - - seen for	1½
	12½

Trochus Schlüteri, *Terebratula carnea*, and a *Micraster* were obtained here.

The next good exposures visible in 1887 were on the hill south of Letcombe Basset, and in the more westerly quarry near Gramps Barn the section was:—

	Feet.
Rubbly white chalk without flints	4
Hard whitish limestone with a layer of green-coated nodules at the top	1½

	Feet.
Hard rubbly chalk, whitish and passing into rock above, grey and looser below	3
Two layers of hard rock with green grains, each having a layer of green-coated nodules at top, and each passing down into hard lumpy chalk	4
Green-coated nodules and layer of hard rock	1½
	14

Hardly any fossils were to be found, and in comparing this section with the preceding it seems clear that what is wholly nodular chalk for 3½ feet in the former is here replaced by beds which partly consist of compact limestone.

On Wantage Down there are old excavations of considerable extent, but they do not appear to have been deep.

The rock has also been largely quarried on both sides of the plantation north-west of Cuckhamsley Knob. The fossils collected by the late Mr. Montague Smith, and now in the Woodwardian Museum, Cambridge, were obtained chiefly from the old pits on the west side of the plantation. The fossils in this fine collection have recently been described by Mr. H. Woods.* On the east side of the plantation a large pit was open in 1887, and the following section exposed:—

	Feet.
Hard lumpy chalk with Micrasters and Sponges, and a layer of scattered flints	7
Irregular band of greyish chalk about	1
Hard lumpy chalk, as above, but without flints	6
Hard compact limestone with a layer of green-coated nodules at top and another about 3 feet down; green grains occur, seen for	4
	18

From the upper beds I obtained *Micraster Leskei*, *Spondylus spinosus*, and *Coscinopora quincuncialis*. The rock did not seem to yield many fossils, and I did not discover the specially fossiliferous layer worked by Mr. M. Smith. The lumpy or nodular chalk is probably an expansion of the central beds of the Chalk Rock, and consequently referable to the *Hol. planus* zone. Part of the same succession is exposed in a quarry on East Hendred Down, 1½ miles south-west of Chilton, but did not in 1887 show so much of the lumpy chalk. Another pit on Bury Down S.S.W. of Chilton shows just the same succession as at Cuckhamsley. No section in higher beds was seen along the escarpment.

From Chilton Down the zone of *H. planus* runs south eastward into the Compton Valley, and thence for some distance up the branch valley to East Ilsley, where there are old quarries in the rock-beds.

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*See "The Mollusca of the Chalk Rock," Quart. Journ. Geol. Soc., Vol. lii. p. 68, and Vol. liii. p. 377, (1896–1897).

From Compton Downs the outcrop of the Chalk Rock runs northward, and forms the bold flat-topped promontory of Churn Hill. The rock can be seen here and there in road cuttings or on the steep hill-sides between here and Streatley, but there are no good sections.

The Higher Zones.

The zone of *Micraster coranguinum* sweeps eastward from North Wiltshire into Berkshire, north of Hungerford, and probably occupies a considerable area beneath the tracts of Clay-with-flints by Shefford, Welford, Beedon, and Chieveley, but we have not been able to obtain any special information about it.

With regard to the zone of *Marsupites,* since it exists in Hampshire, it is very probable that it comes to the surface again on the northern border of the Eocene tract, especially along the south side of the valley of the Kennet between Kintbury and Newbury.

There is a quarry at Kintbury which was visited by the members of the Geologists Association in 1901,* under the direction of Mr. Osborne White, who describes the chalk exposed therein as very white and soft, and as containing very few flints; but near the top there is a bed of hard rocky cream-coloured chalk, the soft chalk is quarried chiefly for the manufacture of whiting, its purity and the scarcity of flints making it very suitable for this purpose. Fossils are also scarce and few were obtained during the visit of the Association, but these few were forwarded to me and I was able to identify the following:—

Actinocamax granulatus ? (an alveolar end only).
Spondylus sp. (? latus).
Echinocorys scutatus.
Porosphæra globularis.
Ventriculites quincuncialis.

Mr. White specially searched for plates of *Uintacrinus* and *Marsupites* but could not find any. Nevertheless the position of the quarry and the characters of the chalk make it very likely that it belongs to the lower part of the *Marsupites* zone.

Beds which seem to belong to the same part of the chalk are exposed at Shaw, near Newbury, and Mr. Rhodes obtained a fair number of fossils from them, which were identified as the following:—

Actinocamax sp.
Spondylus spinosus.
„ latus ?
Magas pumilus.
Rhynchonella plicatilis.
Terebratula semiglobosa.
Serpula ampullacea.
„ fluctuata.
Echinocorys scutatus.
Galerites albogalerus.
Micraster coranguinum.
Parasmilla centralis.

FOSSILS FROM THE CHALK ROCK BEDS.

Few fossils have been found in the Chalk Rock of Berks except at the quarry near Cuckhamsley or Quichelmsley Knob, a hill about four miles south-east of Wantage. No doubt they are equally common at other places, but little search has been made for them. The late Mr. Montague Smith made a fine collection from Cuckhamsley, and the species have been described, and many of them figured by Mr. H. Woods (see his papers in Quart. Journ. Geol. Soc., Vol. lii. p. 68, Pl. ii., iii., and iv., and Vol. liii. p. 377, Plates xxvii. and xxviii.):—

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* Proc. Geol. Assoc., Vol. xvii. page 389.

The following is a list of the species named by Mr. Woods :—

Cephalopoda.

Nautilus sublævigatus, *d'Orb.*
Ammonites [Prionocyclus] Neptuni, *Geinitz*
„ [Pachydiscus] peramplus, *Mant.*
Baculites bohemicus, *Fritsch*
Crioceras ellipticum, *Mant.*
Hamites sp.
Heteroceras reusseanum, *d'Orb.*
„ sp.
Ptychoceras Smithi, *Woods*
Scaphites Geinitzi, *d'Orb.*

Gasteropoda.

Aporrhais Mantelli, *Gard.*
„ sp.
Avellana cf. Humboldti, *Müller*
Cerithium cuckhamsliense, *Woods*
„ Saundersi, *Woods*
Crepidula sp.
Dentalium turoniense, *Woods*
Emarginula Sanctæ Catharinæ, *Passy*
„ two other species.
Lampusia sp. (=Tritonium)
Natica vulgaris, *Reuss*
Pleurotomaria perspectiva, *Mant.*
Trochus Schlüteri, *Woods*
„ berocscirense, *Woods*
Solariella gemmata, *Sow.*
Turbo Geinitzi, *Woods*

Lamellibranchiata.

Arca cf. Galliennei, *d'Orb.*
„ cf. Geinitzi, *Reuss*
Cardium turoniense, *Woods*
„ cf cenomanense, *d'Orb.*
„ cf mailleanum, *d'Orb.*
Cardita cancellata, *Woods*
Corbis Morisoni, *Woods*
Cuspidaria caudata, *Sow.*
Cyprina [Arctica] quadrata, *d'Orb.*
„ equisulcata, *Woods*
Inoceramus Brongniarti, *Sow.*
„ striatus, *Sow.*
„ sp.
Limopsis sp.
Martesia (?) rotunda, *Woods*
Nucula sp.
Nuculana siliqua, *Goldf.*
Ostrea semiplana, *Sow.*
Septifer lineatus, *Sow.*
Spondylus spinosus, *Sow.*
„ latus, *Sow.*
Trapezium trapezoidalis, *Rœmer*
„ rectangulare, *Woods*

Besides the above the following were found during the survey of the district:—

Terebratula carnea, *Sow.*
Coscinopora quincuncialis, *T. Smith.*
Micraster Leskei, *Desm.*
„ cortestudinarium?, *Goldf.*

CHAPTER XVI.

THE UPPER CHALK IN OXFORDSHIRE, BUCKINGHAMSHIRE, AND THE VALLEY OF THE THAMES.

GENERAL REMARKS.

In this chapter we shall describe the Upper Chalk of Oxfordshire and Buckingham, and shall notice some exposures which are actually on the Berkshire side of the Thames, between Streatley and Maidenhead, but which are naturally included in a purview of the Thames Valley.

The description of this region divides itself naturally into two parts, (1) that of the escarpment ridge and the valley-heads by which it is breached, (2) that of the valley of the Thames. Moreover, the valley of the Thames affords a double series of exposures, first in a series of quarries between Whitchurch and Shiplake, and secondly in another series between Wargrave, Henley, and Maidenhead, owing to a dome-shaped uplift which brings up the Chalk Rock with some of the Middle Chalk at and near Henley.

The zone of *Holaster planus* in these counties often presents the aspect recorded by Mr. Hill in 1886,* having some beds of typical Chalk Rock at the base, and generally about 5 feet thick, succeeded by 14 or 15 feet of rough, lumpy, and nodular chalk, at the top of which there is sometimes (but not always) a second bed of hard yellowish limestone.

The zone of *Micraster cortestudinarium* consists of a variable series of beds, some of firm white massive chalk, some of rough lumpy chalk with occasional courses of hard yellowish rocky chalk, somewhat resembling Chalk Rock, but less compact, and never containing green nodules.

These beds of nodular chalk and of hard chalky limestone form steep slopes, and it is to them that the picturesque features of what is known as the gorge of the Thames between Streatley and Pangbourn are due.

The zone of *Micraster coranguinum* consists for the most part of soft white chalk in regular beds, with numerous regular layers of flints, and in the lower part of the zone the layers of flints are chiefly of the sort called *cariés* by Hébert, rough outside and cavernous within, containing remains of sponges, among which feet of the quarry-face is inaccessible, so that only the lower part was measured, the rest being estimated by eye :—

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*Quart. Journ. Geol. Soc., Vol. xlii. p. 244.

		Feet.
	White halk with flints - - - - - - - about	12
	Soft white chalk without flints - - - - - ,,	2
Zone of *H. planus*	Soft powdery chalk with hard lumps which weather out prominently; contains a few scattered flints and a layer of flints at the base. *Micraster præcursor* common - - - - - - -	16
	Hard compact rock with a layer of green-coated nodules at top; below it passes into lumpy white chalk - - - - - - - - - - -	2
	Hard yellowish rock full of green-coated nodules in the upper 6 inches, compact below but passing into nodular chalk - - - - - - - -	3
Middle Chalk.	Less nodular white chalk passing into massive white chalk - - - - - - - - - - -	6
	Layer of grey marl just seen.	
	Talus hiding lower beds - - - - - - -	20
		61

There was no sign here of any rock-bed at the summit of the lumpy chalk, but the soft white chalk may be regarded as the base of the zone of *Micraster cortestudinarium*. The Chalk Rock below has but few fossils.

Another good section, where every bed can be easily examined, is in the road cutting on White Hill, east of Goring, and here the upper limit of the zone is marked by a thin bed of yellowish rock. The beds seen are as follows :—

		Feet.
	Soft white chalk with a layer of flint about half an inch thick at the base - - - - - - - - - - - - -	5
Zone of *Holaster planus.*	Hard yellowish rock in loose lumps, but without nodules. *Ventriculites* - - - - - -	1
	Nodular chalk, consisting of hard limestone lumps embedded in loose powdery chalk with a few scattered flints - - - - - - - -	12
	Hard white limestone, without green grains, passing down into very hard compact yellowish rock full of green grains, with several layers of green-coated nodules (Chalk Rock) - - - - - -	5
Middle Chalk.	Hard rock without green grains passing down into rough nodular chalk - - - - - - -	2
	Layer of soft shaly marl - - - - - - -	½
	Firm bedded white chalk - - - - -	4
	About	30

Micrasters were here rare, but *Echinocorys scutatus*, *Spondylus spinosus*, and *Terebratula carnea* occurred in the nodular beds.

The next good section was in a quarry on Aston Hill, by the side of the road from Oxford to London. In 1887 this showed :—

		Feet.
	Soft thin-bedded chalk with a layer of flints in the middle -	6
Zone of *Holaster planus.*	Compact yellowish rock - - - - - - -	1
	Dull white lumpy chalk, consisting of soft mealy chalk with hard lumps, very glauconitic at the base. Many fossils - - - - - - -	14
	Loose rubbly rock with green grains, green-coated nodules, and many fossils - - - - -	1
	Compact cream-coloured rock with a layer of nodules about 2 feet down - - - - - seen for	4
		26

A similar section showing the two rocks with 14 feet of intervening nodular chalk and about 10 feet of overlying chalk with flints is shown in a quarry, about 30 feet deep, by the main road near the top of Chinnor Hill. Fig 53 represents this quarry as seen in 1887.

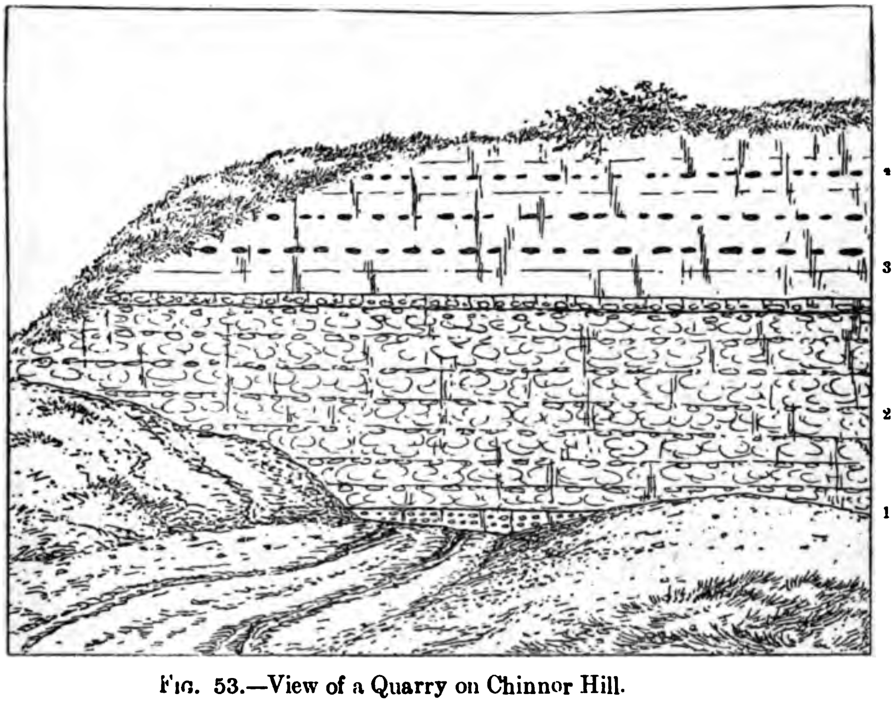

Fig. 53.—View of a Quarry on Chinnor Hill.

4. Chalk with several layers of flints.
3. Upper bed of yellowish Chalk Rock.
2. Nodular chalk, hard lumps in soft mealy chalk.
1. Lower bed of rock with green grains and nodules.

Mr. J. Rhodes made good collections of fossils from these quarries on Aston and Chinnor Hills, and lists will be found at the end of this chapter, but at the present time both sections are obscured by talus.

In Bucks there are many exposures of "Chalk Rock" along the sides of the valleys which breach the escarpment, and of the smaller valleys which open into them, but it is often difficult to say whether the particular rock exposed is at the base or top of these beds. Moreover, some sections show a succession of rock beds like those in some parts of Wiltshire, and no exposure has yet been seen in this county which shows a complete section through these beds. The following are records of some of the best exposures :—

Some small pits at the end of Bledlow Ridge combine to show a succession like that in the quarries on Chinnor and Aston Hills, in Oxfordshire, viz., a lower hard and compact rock, nodular chalk for about 10 or 12 feet, and a thin upper rock, with some green grains and yellowish lumps.

A pit on the hill about a mile east of Princes Risborough gave the following section of the Chalk Rock :—

	Ft.	*in.*
Rough nodular rocky chalk - - - - - - -	3	0
Layer of green-coated nodules - - - - - -	0	2
Smooth yellowish chalk with hard concretionary lumps -	3	0
Green-coated nodules forming a layer at the top of rough nodular chalk - - - - - - -	2	8
Large yellowish nodules at the top of a bed of hard nodular yellowish limestone, probably the basal bed - -	1	0
Nodular white chalk passing down into softer smooth chalk - - - - - - - - -	5	0

The nodular chalk at the top yielded *Holaster planus*, *Micraster*, *Am.* [*Pachydiscus*] *prosperianus*, and *Terebratula carnea*. The lower beds contained *Am.* [*Prionocyclus*] *Neptuni* and a few other fossils (see p. 213.)

Another good section of the junction of the Middle and Upper Chalk is visible in a chalk-pit at Great Missenden, 300 yards north of the church. The upper part was inaccessible at the time of my visit in 1885, but the thicknesses could be roughly estimated by eye, the succession being as follows :—

		Feet.
	Soil and rubble - - - - - - -	2
Chalk Rock.	Rocky layer with yellowish nodules, overlying nodular chalk with other layers of nodules - - -	6½
	Nodular chalk, hard at the top - - - -	1½
	Hard yellowish compact rock with brownish phosphatic nodules at the top - - - -	1
	Soft white chalk in massive beds with three marly layers	29

Sections in the Henley Inlier.

This inlier is of very irregular shape, the outcrops of the Chalk Rock extending from the southern part of Henley up the Fair Mile Valley to and beyond Middle Assendon, and along the northern

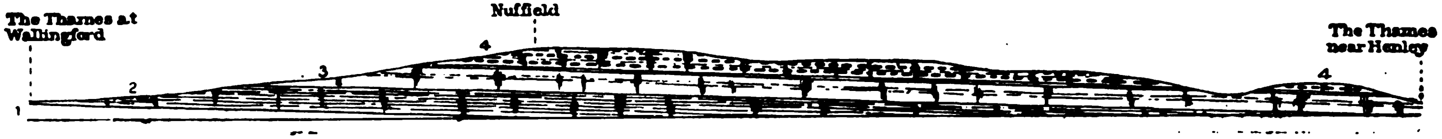

Fig. 54.—Section through part of Oxfordshire from Wallingford to Henley.

Horizontal Scale, 1½ mile to one inch. Vertical Scale, 1,600 feet to an inch.

4. Upper Chalk.
3. Middle Chalk.
2. Lower Chalk.
1. Upper Greensand.

side of the Thames Valley to Medmenham, as well as for some distance up the tributary valley beyond Hambledon.

Mr. Whitaker has recorded a curious local disturbance in a pit just south of Middle Assendon, where the Chalk Rock is exposed, with dips in three directions, the sharpest being down the slope of the side of the main valley; in this direction it dips at 10° to 25° south of west, and in the opposite direction (25° north of east) it dips at 4°, while there is a lesser dip of about 2° to the north-west.

A more complete section of the Rock and its associated beds is visible in a large quarry at the entrance to Henley Park, about a mile north of the town. This pit is not now quarried, but the following particulars of the section were taken by Mr. Hill in 1886:—

		Feet.
White chalk with several layers of flints		15
Zone of Holaster Planus.	Nodular chalk, consisting of hard lumps in a matrix of soft mealy chalk, with a few scattered flints—not regularly bedded	9
	Similar chalk, hard lumps in a soft matrix, no flints, except in a layer at the base, *Micraster præcursor* and *Ter. semiglobosa*	10 to 12
	Chalk Rock. Hard yellowish crystalline chalk with green-coated nodules, upper surface clearly marked, but not the lower limit	?5
Rather hard white chalk with a marly layer about 5 feet down - seen for		7
	About	48

The best existing section is in a large quarry now worked less than half a mile west of Medmenham. For the following account of this section I am indebted to Mr. Hill, who visited it in 1899:—

		Ft.	*in.*
Smooth white chalk with a few thin-skinned black flints (inaccessible in part) - over		10	0
Continuous seam of flint		0	1
Firmer white chalk, slightly lumpy but not rough, a few scattered flints, *Echinocorys scutatus*		4	0
Soft white chalk with many scattered flints		1	0
Zone of H. Planus.	Irregular lumpy white chalk with a very few small scattered flints, one *Micraster præcursor* found	12	0
	Chalk Rock. Hard creamy white limestone with two layers of green-coated nodules, the lower part passing down into firm white chalk	5	8
Firm white chalk in thick massive beds, seen for about		40	0
	Over	70	0

It will be noticed that this section differs from all those previously described, the beds above the Chalk Rock being much less nodular than usual, with fewer fossils, and soft white chalk coming on only 12 feet above the Chalk Rock, instead of about 20 feet above, as near Henley.

All the sections in Oxfordshire certainly favour the view that the actual Chalk Rock might be taken as the top of the Middle Chalk, the beds resting on it being regarded as the base of the Upper Chalk. This was the view taken by Mr. Hill in 1886,* but a more extended experience has shown that elsewhere it is difficult to separate the rock from the beds above.

FOSSILS FROM THE CHALK ROCK BEDS.

	Oxfordshire.		Buckinghamshire.		
	Aston Hill.	Chinnor Hill.	Bledlow.	Risborough.	Wycombe.
Cephalopoda.					
Ammonites [Prionoc.] Neptuni, *Gein.*	–	–	–	x	–
„ [Pachyd.] peramplus, *Mant.*	x	–	–	x	–
„ „ Wiesti ? *Sharpe*	x	–	–	–	–
Baculites bohemicus, *Fritsch*	–	–	–	x	–
Hamites sp.	x	–	–	–	–
Heteroceras (? reussianum, *d'Orb.*)	–	x	–	–	–
Scaphites Geinitzi, *d'Orb.*	x	x	–	x	–
Gasteropoda.					
Avellana Humboldti, *Müller*	x	–	–	–	–
Cerithium sp.	x	x	x	–	–
Dentalium turoniense, *Woods*	x	–	–	–	–
Emarginula (cast)	–	x	–	–	–
Nerinæa sp.	x	–	–	–	–
Pleurotomaria depressa, *Mant.*	x	–	–	–	–
„ perspectiva, *Mant.*	x	x	x	x	–
Trochus sp.	x	–	x	–	x
Solariella gemmata, *Sow.*	–	x	–	–	–
Turbo Geinitzi, *Woods*	x	?	–	–	–
Lamellibranchiata.					
Arca sp.	–	x	–	–	–
Cardita cancellata, *Woods*	x	x	x	–	–
Nucula sp.	–	–	x	–	–
Inoceramus Cuvieri ? *Sow.*	–	–	–	x	–
„ sp. (small)	–	x	x	x	x
Ostrea normaniana, *d'Orb.*	–	x	x	–	x
„ vesicularis, *Lam.*	–	x	–	–	–
Spondylus latus, *Sow.*	–	–	x	–	–
„ spinosus, *Sow.*	x	x	x	x	x
Trapezium trapezoidalis, *Roemer.*	–	–	x	x	–
Brachiopoda.					
Rhynchonella Cuvieri, *d'Orb.*	x	x	–	–	–
„ plicatilis, *Sow.*	x	x	–	–	–
„ reedensis, *Eth.*	x	–	x	–	x
Terebratula abrupta ? *Tate*	–	–	x	x	–
„ carnea, *Sow.*	x	–	–	x	–
„ semiglobosa, *Sow.*	x	x	x	x	x
Terebratulina striata, *Wahl.*	–	–	x	–	–

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* See Quart. Journ. Geol. Soc., Vol. xlii. p. 244.

Fossils from the Chalk Rock Beds—continued.

	Oxfordshire.		Buckinghamshire.		
	Aston Hill.	Chinnor Hill.	Bledlow.	Risborough.	Wycombe.
Bryozoa.					
Diastopora echinata, *d'Orb* (Berenicea).	x	–	–	–	–
„ grandis, *d'Orb.* „	–	x	–	–	–
Proboscina ramosa, *Edw.*	x	x	–	–	–
Echinodermata.					
Cidaris hirudo, *Sorig.* (spines).	–	x	–	–	x
Echinocorys scutatus, *Leske*	x	x	–	–	–
Holaster planus, *Mant.*	x	x	–	x	x
Micraster Leskei ? *Desm.*	x	x	–	x	x
„ præcursor, *Rowe*	x	x	–	–	x
Annelida.					
Serpula ampullacea, *Sow.*	–	x	–	–	–
„ fluctuata, *Sow.*	x	–	–	–	–
„ granulata, *Sow.*	x	–	–	–	–
„ ilium, *Sow.*	x	–	–	–	–
„ plexus, *Sow.*	–	x	x	–	–
Actinozoa.					
Caryophyllia sp.	x	x	–	–	x
Parasmilia centralis, *Mant.*	x	x	x	x	x
Spongida.					
Coscinopora infundibuliformis, *Goldf.*	x	–	–	–	–
Guettardia stellata, *Mich.*	x	–	x	–	–
Placotrema cretaceum, *Hinde*	x	–	–	–	–
Plocoscyphia convoluta, *T. Smith*	x	x	–	–	x
Ventriculites alcyonoides, *T. Smith*	–	–	–	x	–
„ decurrens, *T. Smith*	–	–	x	–	–
„ impressus, *T. Smith*	x	x	–	x	–
„ radiatus, *Mant.*	–	x	–	–	–

Zone of Micraster cortestudinarium.

This zone is nowhere well exposed along the course of the escarpment ridge either in Oxford or Bucks; but in the valley of the Thames there seems to be some thickness of chalk, exposed in several pits, which is referable to this zone.

Part of this zone is well exposed in the railway cutting west of Pangbourn, where the beds are bent up into a slight anticlinal curve, as represented in Fig. 55, and the succession noted in 1885 was as follows:—

	Ft.	in.
10. Chalk with some flints	0 to 6	0
9. A continuous seam of flint	3	0
8. Chalk without flints	4	0
7. Chalk with three layers of flint nodules	5	0
6. Chalk with a few flints	10	0
5. Yellow rocky chalk, enclosing some flints	0	9
4. Chalk with scattered flints	4	0
3. Hard yellowish rocky chalk	1	0
2. Rough chalk with flint nodules	2	0
1. Massive homogeneous chalk - - - seen for	1	3
	30–35	0

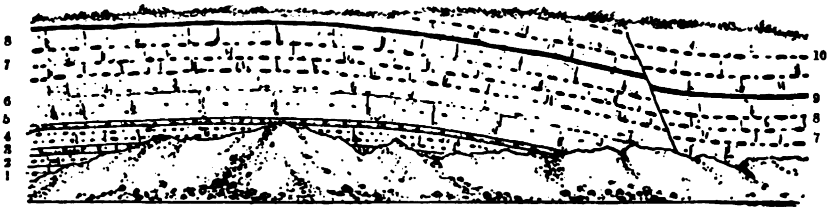

FIG. 55.—Sketch in the Railway Cutting west of Pangbourn.

The fault is of small importance, having a throw of about 2 feet. The flints are black inside, with a very thin rind, and some of them are cavernous. *Echinocorys scutatus* was the only fossil seen.

Prof. Barrois mentions a quarry "north of Pangbourn" which he refers to the zone of *M. cortestudinarium*,* and this must be the exposure at Whitchurch, north of the village, behind the school house on the main road; in 1885 it showed a good vertical face of chalk with many layers of flints. The chalk is firm, but not hard; the flints occur in layers, or courses, 4 to 6 inches thick, full of flints crowded together, and these courses are from 2 to 3 feet apart; there are also some scattered nodules between the courses and some thin continuous seams of flint.

Prof. Barrois records *Micr. cortestudinarium* and *Inoceramus Cuvieri* from the lower part of the pit, and says there is a bed of hard yellowish nodular chalk about 20 feet from the top. Mr. H. J. Osborne White has recently visited this quarry and found a few fossils in a band from 5 to 7 feet above the present floor of the pit; these he kindly sent to me, and they proved to be *Cidaris sceptrifera* (part of a test), *C. clavigera* (spine), with some remains of sponges in flint and fragments of *Inoceramus*-shell.

Mr. White also informs me that there are two other quarries, one about half a mile, the other a mile east of Whitchurch. The first of these (near Rosedown Farm) is probably that visited by Prof. Barrois (see op. cit.), and from which he obtained the following fossils:—

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* Recherches sur le Terr. Crét. Sup. p. 148 (1876).

Inoceramus involutus.
„ Cuvieri.
Rhynchonella plicatilis.
Cidaris clavigera.
Echinocorys gibbus.
Micraster cortestudinarium.
Starfish remains.
Porosphæra globularis.

As already mentioned, the base of the Upper Chalk is brought up again by the Henley anticline, and there is an old quarry above the church at Remenham which seems to be in the zone of *M. cortestudinarium*. Mr. Osborne White informs me that it is about 25 feet deep, and that there are several layers of hard greyish lumpy chalk from 5 to 15 feet above the floor of the pit. In these he found several *Micraster præcursor* (of decidedly low zonal type, with feebly inflated interporiferous areas), *Echinocorys gibbus*, *Spondylus spinosus*, *Terebratula semiglobosa* and *Ventriculites quincuncialis*. Flints occur as small scattered nodules, and in their continuous (or tabular) layers. The chalk above is soft and white.

Further east near Medmenham there are two quarries which were visited by Mr. Hill in 1899, who supplies the following particulars:—

"A quarry at Medmenham, north of the church, shows some 40 to 45 feet of chalk, but the face is inaccessible except near the base. The lower 10 feet consisted of lumpy chalk of irregular texture, and above this is a layer of large flints rather widely separated. The next 20 feet contained many scattered flints and one prominent flint-floor. The highest part consists of massive chalk with large rough flints in irregular layers.

The other quarry, 1¼ mile east of Medmenham, showed the following section:—

	Ft.	*in.*
Chalk with flints (inaccessible) - - - - - - -	20	0
Two continuous seams of flint with chalk between - -	0	6
Firm white blocky chalk, without flints, *Micraster præcursor*, *Echinocorys scutatus*, *Cidaris sceptrifera*, and many shell-fragments - - - - - - - -	3	6
Firm white chalk in two courses, the lower containing many scattered flints and shell-fragments - - -	3	9
Firm blocky chalk with few flints - - - - -	1	6
Firm chalk with scattered flints, *Echinocorys* - - -	3	6
Massive creamy white chalk, somewhat lumpy - - -	5	0
Firm white chalk with a few scattered flints - - -	4	3
Hard rough lumpy chalk, passing down into softer white chalk, *Echinocorys scutatus* - - - - -	2	6
Two floors or seams of flint, each 3 inches thick, with 18 inches of chalk between them - - - - -	2	0
Irregular lumpy chalk - - - - - - seen for	4	0
	50	6

The flints are black, with thin rinds, and the two seams near the base thin out, the one toward the west and the other toward the east, so that the one seems to take the place of the other.

The upper part of this succession may belong to the zone of *M.*

coranguinum, but the fossils found were not sufficient to determine the point; it is noticeable, however, that the upper beds are full of shell fragments, which are wanting in the lower 20 feet.

Another quarry which appears to expose the upper part of this zone is one by Marlow waterworks, north-west of the town. Of this pit I have only a brief note furnished by Mr. Rhodes, who was instructed to collect from it in 1888. He describes it as about 60 feet deep, the upper part inaccessible, but showing chalk with layers of flints; from the lower 20 feet, which consists of greyish white chalk with flints, he got many fossils, including Micrasters of the low-zonal forms. (See list at end of chapter.)

Zone of Micraster coranguinum.

The only noteworthy exposure of this zone along the escarpment ridge is in a quarry on Watlington Hill, a quarter of a mile south-west of Portways, at a height of 750 feet, and consequently about 140 feet above the base of the Chalk Rock beds. The chalk seen is rather hard, and contains a hard yellowish rocky band; there are many flints, both scattered and in layers, and most of them hollow, enclosing remains of sponges (chiefly *Doryderma ramosum*); some are pink, others grey or nearly black.

Along the valley of the Thames exposures of this zone are much more numerous, and the following account has been drawn up from the records published by Professor Barrois,* supplemented by notes furnished by Mr. W. Hill and Mr. J. Rhodes.

Being unable to indicate any particular bed as the top of the zone of *M. cortestudinarium*, and fossils being scarce in the beds which form the passage from it to the zone of *M. coranguinum*, we cannot be sure about the zonal horizon of some exposures. It is probable, however, that all the chalk seen in the numerous quarries along the Oxford side of the river from near Hardwick House to Shiplake belongs to the zone of *M. coranguinum*.

At Mapledurham and at Chase Farm, west of Caversham, there are quarries which are unquestionably in the zone of *M. coranguinum*, the chalk being soft white, with few perfect fossils, but many fragments of large *Inoceramus*; the flints are in layers from 2 to 3 feet apart, and some of them are with a cloudy white band, while others are cavernous and contain numerous Bryozoan remains. The quarry at Chase Farm is about 80 feet deep.

At Caversham is another large quarry, the chalk of which Prof. Barrois referred to the zone of *Marsupites*, but he did not find any plates of that Echinoderm, and Mr. Hill, who has recently visited it, saw no reason for separating this chalk from that of Chase Farm, its general aspect being the same, the flints nearly as numerous, and no layer of yellow nodules nor any other special feature being visible in either quarry. Prof. Barrois describes the chalk of the

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* Recherches sur le Terr. Crét. Sup., p. 148 (1876).

Caversham quarry as "white and soft, with layers of flints from 3 to 6 feet apart. These flints are black, with a thin white skin; some are cavernous, others in tabular layers; their shape is irregular, generally flattened in the direction of the stratification." He found the following fossils:—

Inoceramus (rare).
Lima Hoperi.
Spondylus.
Rhynchonella plicatilis.
Terebratulina striata.
Serpula granulata.
Cidaris clavigera.
,, hirudo.
Micraster coranguinum.
Bourgueticrinus ellipticus.
Porosphæra globularis.

It will be observed that there is nothing here specially characteristic of the higher zone.

There are several pits between Caversham and Shiplake, and Mr. Hill reports them all to be in chalk with many layers of flints, with very few fossils, and without special features. He refers them all to the zone of *M. coranguinum.*

South-east of Wargrave, in Berkshire, is a large quarry, 60 feet deep, in similar chalk, and the same chalk can be seen at several places on the river slope between Wargrave and Park Place.

As already stated, an anticlinal flexure brings up lower beds near Henley, and for some distance to the westward on the north side of the valley, but the zone of *M. coranguinum* is exposed at several places on the southern side.

There is a large quarry by the main road, about a mile south of Remenham, which was seen by Mr. Hill in 1899, but he found a vertical and inaccessible face of chalk, apparently of similar homogeneous character throughout, with many layers of flints, which are of a dark greyish black inside.

A small quarry half a mile south-east of Bisham Abbey shows chalk with many flints, most of which are cavernous and contain sponge remains (chiefly *Doryderma ramosum*). A little south of this, by Bisham Wood, and at a much higher level, is a large quarry which was visited by Mr. Rhodes in 1880; he reported that it showed about 60 feet of chalk with layers of black flint nodules, and that fossils were fairly abundant, *Ostrea acutirostris* occurring in a layer about 4 feet from the base of the pit associated with fragments of a large *Inoceramus.*

Further south, at Pinkneys, and again at Littlewick Green, are other quarries from 30 to 50 feet deep; Mr. Rhodes obtained a fair number of fossils from these, and reported the layers of flints to be numerous, and the flints to be greyish-black inside. The fossils included:

Cidaris hirudo.
,, perornata.
,, sceptrifera.
Galerites albogalerus.
Micraster coranguinum.
Bourgueticrinus sp.
Serpula plana.
,, turbinella.
Rhynchonella reedensis?
Terebratula semiglobosa.
Pecten cretosus.
,, (Neithea) quinquecostata.
Inoceramus Cuvieri?
Ostrea acutirostris.
Lima sp.

The Taplow Chalk.

In 1889 Mr. J. Rhodes, while collecting fossils near Maidenhead, discovered a quarry by the lodge of Taplow Court which exhibited a remarkable section, and from which he obtained many specimens of *Actinocamax granulatus*. This quarry was subsequently visited by Mr. A. Strahan, who described it and the phosphatic chalk found there in some detail.* From this description the following account is taken, but the bracketing of the beds in the section is my own:—

Section in Quarry at Taplow.

		Ft.	*in.*
Taplow Chalk.	Soft white chalk, passing down into next -	12	0
	Brown chalk with *Ostrea acutirostris*, *Actinocamax granulatus*, *Echinocorys scutatus*, and *Cidaris sceptrifera* - - - - - -	8	0
	White chalk traversed by numerous tubes and cavities filled with brown chalk; a hard and blocky top, forming a marked floor to the brown chalk above - - - - - - -	3	0
	White chalk, mostly inaccessible, and not examined in detail - - - - - - - - - -	14	0
	White chalk with scattered brown grains - -	2	6
	Brown chalk - - - - - - - -	4	0
	Hard crystalline chalk with nodular structure and greenish markings - - - about	1	0
Micraster coranguinum zone.	White chalk [hard at the top] and piped with brown chalk as above - - - -	1	10
	A [thin] sandy brown layer- - - - -	0	0½
	White chalk, piped with brown chalk - -	2	6
	White chalk to the bottom of the pit, the first flints occurring 12 feet below the lower band of brown chalk, *Galerites albogalerus* -	15	0
	About	64	0

The beds dip at 4 or 5 degrees, about E. 10 S.

A shaft subsequently sunk in the hillside above the pit gives the exact depth of the phosphatic chalk below the base of the Tertiary strata. The following were the measurements of the beds traversed by this shaft:—

		Feet.
Reading Beds.	Clay - - - - - - - - - - -	7
	Greensand with green-coated flints - - - -	2½
Upper Chalk.	White chalk - - - - - - - - - -	18
	Brownish white chalk - - - - - - -	2
	Brown chalk (upper phosphatic band) - - -	11
	Hard white chalk - - - - - - - -	12
	Soft brown chalk (lower phosphatic band) - - -	4
	Very hard white chalk.	
		56½

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* Quart. Journ. Geol. Soc., Vol. xlvii. p. 356 (1891).

Mr. Strahan observes:—"Both the [brown] bands owe their colour to a multitude of brown grains, and pass up gradually into a rock less rich in brown grains and of a pale brown or greyish tinge. The chalk is irregularly bedded, perhaps current bedded, and traversed by irregular joints so as to break up readily into blocks, which crumble into a rounded form and finally into powder. Its friability forms a marked feature and is due to the softness of the white chalky paste in which the brown grains are embedded. Under the microscope these grains are seen to be almost entirely of organic origin, foraminifera, prisms of *Inoceramus* shells, and small oval pellets forming the bulk. . . . .

"Below both bands of brown chalk there occur some few feet of white chalk traversed by cavities and tubes of all shapes and sizes up to an inch in diameter and filled with brown chalk. The top of this piped chalk is in both cases hard, crystalline, and of a nodular structure, so as to form a clearly marked floor to the soft brown chalk."

Fossils are very scarce in the lower part of the section, but Mr. Rhodes obtained *Galerites albogalerus* near the bottom. As no plates of *Marsupites* were found, it is doubtful whether any part of the section is referable to the zone of *Marsupites*, and it certainly cannot belong to the zone of *Act. quadratus.*

The dip being to the south of east, lower beds occur to the north wards, and Mr. Strahan found that "a great thickness of flinty chalk has been laid bare in the Root-House Pit, and almost certainly lies at a lower horizon than the phosphatic chalk. The lower part of the northern end of the pit exposes a nodular band resembling Chalk Rock." Chalk has been dug below the gravel about 300 yards east of Taplow Station, and this is also chalk with many flints, belonging to the *M. coranguinum* zone.

North of Burnham, and about two miles north-east of the Lodge Pit, is a quarry exposing the junction of the Chalk and Eocene. Mr. Strahan says of this: "A thickness of about 8 feet of chalk is exposed, but none of the rock possesses the characters of the phosphatic chalk of Taplow. It contains but one layer of flints near the top, but a pale greenish layer [is seen] about 5 feet down."

He did not succeed in finding any other outcrop of the phosphatic chalk, but concluded that it underlies the greater part, if not all, of the outlier of Tertiary strata on which Taplow stands. He thinks, however, that it is strictly of local occurrence.

FOSSILS FROM THE UPPER CHALK IN THE THAMES VALLEY.

The following is a list of the fossils obtained chiefly by Mr. J. Rhodes from pits on both sides of the River Thames between Whitchurch and Taplow. It is now thought that most of the exposures are in the zone of ***Micr. coranguinum,*** but the quarries near Whitchurch and Marlow yielded the list given in the first column :—

—	Zone of M. cortestudinarium.	Zone of M. coranguinum.	Taplow Chalk.
Fish.			
Cimolichthys lewesiensis, *Leidy*	–	x	–
Fish remains	–	x	–
Cephalopoda.			
Actinocamax granulatus, *Blainv.*	–	–	x
„ sp. (? verus)	–	x	–
Scaphites sp.	x	–	–
Lamellibranchiata.			
Inoceramus Brongniarti, *Sow.*	–	x	–
„ Cuvieri ? *Sow.*	x	–	–
„ involutus, *Sow.*	x	x ?	–
Lima Hoperi, *Sow.*	–	x	–
Ostrea acutirostris, *Nilss.*	–	x	x
„ normaniana, *d'Orb.*	–	x	–
„ sp.	x	x	–
Pecten cretosus, *Defr.* (=Nitidus, *Mant.*)	–	x	–
„ (Neithea) quinquecostatus, *Sow.*	–	x	–
Spondylus spinosus, *Sow.*	x	–	–
„ sp.	–	x	–
Brachiopoda.			
Crania egnabergensis, *Retz.*	–	x	–
„ parisiensis, *Defr.*	–	x	–
Kingena lima, *Defr.*	–	x	–
Rhynchonella reedensis, *Eth.*	–	x	–
„ plicatilis, *Sow.*	x	x	–
Terebratula semiglobosa, *Sow.*	x	x	–
Terebratulina striata, *Wahl.*	–	x	–
Bryozoa.			
Diastopora sp.	–	x	–
Entalophora sp.	–	x	–
Escharina sp.	–	x	–
Idmonea sp.	–	x	–
Membranipora arborea, *d'Orb.*	–	x	–
„ normaniana, *d'Orb.*	–	x	–
„ sp.	–	x	–
Proboscina angustata, *d'Orb.*	x	–	–
„ ramosa ? *Edw.*	x	–	–

—	Zone of M. cortestudinarium.	Zone of M. coranguinum.	Taplow Chalk.
Annelida.			
Serpula ilium, *Goldf.*	–	x	–
„ granulata, *Sow.*	–	x	–
„ plana, *Woodw.*	–	x	–
„ plexus, *Sow.*	–	x	–
„ turbinella, *Sow.*	–	x	–
Terebella lewesiensis, *Davies*	–	x	–
Echinodermata.			
Bourguetierinus sp.	–	x	–
Cidaris clavigera, *Mant.*	x	x	–
„ hirudo, *Sorig.*	–	x	–
„ perornata, *Forbes*	–	x	–
„ sceptrifera, *Mant.*	x	x	x
„ subvesiculosa, *d'Orb.*	–	x	–
Cyphosoma sp.	–	x	–
Echinocorys scutatus, *Leske*	x	x	x
Galerites albogalerus,	–	x	–
Holaster sp.	–	·	–
Micraster coranguinum, *Leske*	–	x	–
„ cortestudinarium, *Goldf.*	x	x	–
„ præcursor, *Rowe*	x	x	
Spongida.			
Coscinopora infundibuliformis, *Goldf.*	x	–	–
Doryderma ramosum, *Mant.*	–	x	–
Guettardia stellata, *Mich.*	x	x	–
Plocoscyphia convoluta, *T. Smith*	x	–	–
Porosphæra urceolata, *Phil.*	–	x	–
„ globularis, *Phil.*	x	x	–
Thamnospongia sp.	–	x	–
Ventriculites impressus, *T. Smith*	x	–	–
„ mammillaris, *T. Smith*	x	–	–
„ radiatus, *Mant.*	x	–	–
„ sp.	x	–	–

CHAPTER XVII.

THE UPPER CHALK IN BEDFORDSHIRE, HERTFORDSHIRE, AND MIDDLESEX.

GENERAL REMARKS.

No great thickness of Upper Chalk comes to the surface in these counties, and along the main escarpment the exposures are chiefly in the lowest beds (Chalk Rock, etc.). Chalk, however, is exposed along many of the valleys which open to the eastward and south-eastward, and in some of these inlying tracts large quarries have been opened, especially in parts of Hertfordshire and Middlesex.

There are three deep borings in Hertfordshire which give us some information regarding the thickness of the Upper Chalk below the Eocene to the eastward. The first of these is at Bushey,* and specimens from several horizons in this boring were examined by Mr. Hill, who found that the sample registered as coming from 161 to 169 feet down was unmistakably Chalk Rock. As the site of the boring is in the valley below the Eocene boundary the total thickness of Upper Chalk below Watford is probably about 190 feet.

In the boring at Cheshunt the position of the Chalk Rock has not been determined from specimens, but a rock described as "chalk rock" was found at a depth of 363 feet, and is stated to be 15 feet thick; the base of the Eocene is at 102½, and thus there may be 275 feet of Upper Chalk below Cheshunt.†

The third boring was at Ware,‡ and here again no sample of Chalk Rock could be recognised among the specimens examined, but one from 211 feet down was "a good specimen of Middle Chalk"; it is therefore surmised that there must be about 180 feet of Upper Chalk below the alluvium of the river at Ware.

STRATIGRAPHICAL DETAILS.

Chalk Rock Beds (*zone of Holaster planus*).

Near Tring there are no good exposures of this zone; its base is exposed at the Chiltern Waterworks, two miles south-west of Tring, and in 1884 a small hole had been dug in the wood close by, showing 2 or 3 feet of very hard, compact limestone, with some green-coated nodules.

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* See Geology of London by W. Whitaker, Mem. Geol. Survey, Vol. ii. p. 48 (1889).

† See Quart. Journ. Geol. Soc., Vol. l. p. 508 (1894).

‡ *Op. cit.* p. 501.

It is also traversed in the shafts leading down to the bell pits at Hastoe and Northchurch brickyards, south of Tring, the hardest bed being in each case about 1½ feet thick, and known locally as "hurlock."

When the road was made which leads up the hill north-east of Berkhamsted Station, three separate beds of Chalk Rock were exposed, and were seen by Mr. Whitaker in 1863.*

The best section of the rock beds between Tring and Dunstable is in a quarry and the adjacent road-cutting on Pratt's Hill, east of Dagnal. Combining the two exposures they give the following succession:—

		Feet.
	Soil and chalk rubble	2
Chalk Rock Beds	Very hard compact yellowish limestone	1
	Loose nodular chalk, consisting of hard lumps in a very soft matrix	8
	Soft dull white pulverulent chalk	4 or 5
	Hard chalk-rock with a layer of green-coated nodules at top	1½
	Hard nodular chalk with a few finger-shaped flints	2

It will be seen that the thickness of the *H. planus* zone here is about 15 feet. The nodular chalk contains many fossils, and the following were found:—*Solariella gemmata, Spondylus spinosus, Rhynchonella plicatilis, Micraster Leskei, Echinocorys scutatus, Ventriculites impressus,* and *Camerospongia campanulata.*

A pit near the top of the hill east of Valenciennes Farm, south of Dunstable, formerly exposed a good section through the Chalk Rock, but it is now talused and obscured. The following is condensed from Mr. Whitaker's account of it.†

		Feet.
Chalk with nodular flints above, and three continuous seams of flint at the base	about	7
Chalk-rock in three beds, with white chalk between them	„	10
Hard chalk passing down into softer chalk		3

On Five Knoll Hill, south-west of Dunstable, there is a series of excavations from which the rock has been quarried for road material, and from these pits Mr. J. Rhodes obtained many fossils (see list on p. 228).

In the valley of the Ver the rock-beds are exposed in several of the road-cuttings on the slopes, especially near Ailey Green and Markgate Street, and some fossils may be obtained.

The next good section of these beds is in the cutting on the Midland Railway south of Luton, and half a mile north of Chiltern Green Station. For the following account of this section I am

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* See Mem. Geol. Survey, Vol. iv. p. 49 (1872).

† Mem. Geol. Survey Vol. iv. p. 50 (1872).

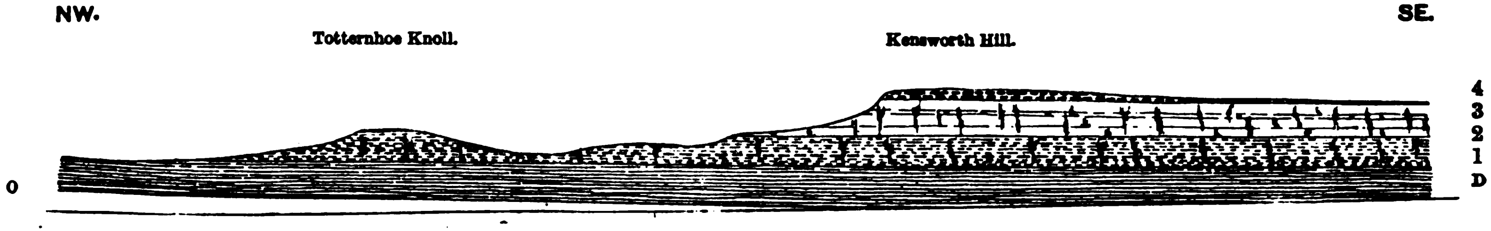

FIG. 56.—Section through Totternhoe Knoll and Dunstable Downs.

Showing the escarpment of Middle Chalk capped by the zone of *Holaster planus*.

Horizontal Scale, 1½ inches to a mile. Vertical Scale, 800 feet to 1 inch.

4. Upper Chalk.
3. Middle Chalk.
2. Lower Chalk.
1. Gault (Upper and Lower).

O.D.—Level of Ordnance datum.

indebted to Mr. J. Saunders, of Luton, who took careful measurements of it in 1894.

		Feet.
	Soft white chalk with many flints - - - - -	24
Zone of *H. planus.*	Hard compact cream-coloured chalk-rock with green-coated nodules - - - - -	2
	Lumpy greyish-white chalk, with a few scattered flints, many Micrasters - - - about	11
	Hard compact cream-coloured chalk rock with green grains and green-coated nodules - -	2
Middle Chalk.	White chalk, lumpy at the top, but most of it in thick massive beds, with scattered flints - -	25
	Thin seam of buff-coloured marl; less than -	½
	Massive blocky chalk - - - - seen for	1½
		72

Many fossils have been found in the zone of *H. planus* at this locality, and a list will be found at the end of this chapter. It will be noticed that the thickness of the zone is here again 15 feet.

From the valley of the Lea the outcrop of the zone passes northward to the high ridge known as Warden Hill, and thence eastward into the valley known as Lilley Bottom. Out of this valley it runs northward again to Great Offley, and thence eastward to Offley Holes and Preston.

The lower beds of the rock, for about four feet in depth, are exposed in a small excavation by the roadside half a mile north-east of Preston, and from this many fossils have been obtained by Mr. W. Hill and myself. The upper part of the rock was exposed in an old quarry near Temple Dinsley House, and the zone hereabouts appears to consist of two bands of Chalk Rock, each about 5 feet thick, separated by a band of lumpy chalk, the whole probably from 16 to 18 feet.

Thence the outcrop of the rock has been traced to Hill End Farm, and Almshoe Bury. Between this and Stevenage the Chalk Rock is concealed by drift, but it emerges to the north-east near Chisfield, and can be traced continuously along the escarpment to Clothall, Wallington, and the country south of Royston. The rock-beds are well exposed in two quarries near Clothall, one north-east of, and the other half a mile west-south-west of, the church; the latter is the deeper, and shows the following section:—

		Ft.	*in.*
	Clay soil and flints - - - - - - - -	1	0
	Hard chalk with many flints of various sizes and shapes -	4	0
Chalk Rock.	Hard nodular chalk, rough, lumpy, and cream-coloured, with many fossils - - - -	5	0
	Irregular layer of soft dusty yellowish chalk - -	0	9
	Chalk consisting of hard lumps in a softer matrix -	4	6

The upper five feet of the rocky chalk contain a few scattered flints and small pieces of light brown phosphate.

The Chalk Rock has also been quarried in a pit about a third of a mile north-west of Wallington church, which must originally have shown the base of the rock, but when I saw it in 1884 this was concealed by talus. Subsequently, however, Mr. Hill made a trench through this talus, and exposed the base of the rock at a depth of about 16 feet from the top of the pit. When clear, therefore, this section showed :—

	Feet.
Nodular chalk, much weathered, the soft chalk between the hard lumps crumbling into yellowish chalk dust. Scattered flints. *Micraster*, *Holaster planus*, &c. - - - - -	10
Similar chalk (now concealed by talus) - - - - -	3
Hard yellowish rock, with a few green-coated nodules, much jointed and broken up - - - - - - - - -	3
Soft white marly chalk with a few flints, the lower part concealed by talus (zone of *Terebratulina*) - - - -	8

The flints in the nodular chalk are of the carious or cavernous type, very rough outside, and full of cylindrical holes, which doubtless once contained the remains of sponges. Nodular chalk like the above is also exposed in a small pit near Roe Green.

East of the main outcrop the Chalk Rock borders the inlying tract of Middle Chalk by Weston, Cromer, and Walkern, in valleys which drain into the River Bean. It was formerly quarried in a pit half a mile east of Weston, where in 1884 I saw 4 feet of nodular chalk overlying a foot of very hard compact rock with a layer of green-coated nodules at top, but passing down into tough nodular chalk with some scattered flints. The rock contained *Inoceramus striatus*, *Rhynchonella reedensis*, *Terebratula carnea*, *Micraster Leskei* and *Plinthosella squamosa* (identified by Dr. Hinde).

It will be noticed that the thickness and aspect of the rocky beds forming the zone of *H. planus* in these counties vary very considerably.

LIST OF FOSSILS FROM THE CHALK-ROCK BEDS IN BEDFORDSHIRE AND HERTFORDSHIRE.

A considerable number of fossils have been obtained from some of the localities where these beds are exposed, as the following lists will testify. That from Boxmoor is taken from "The Geology of London" (Mem. Geol. Survey, 1889, pp. 73–74), but the nomenclature has been revised in accordance with the identifications of Mr. H. Woods (see Quart. Journ. Geol. Soc., Vol. lii. p. 68, and Vol. liii. p. 377).

The list of column 2 is based on a collection made by Mr. Rhodes from the pits on Five Knoll Hill, near Dunstable, supplemented by smaller collections made by Mr. Whitaker and myself at at Markgate Street and Ailey Green.

The third column is based on collections from the railway cutting south of Luton, made by Mr. Rhodes, Dr. Morison, and Mr. J. Saunders. Nearly all the mollusca in these collections were seen and identified by Mr. Woods; most of the other fossils were named by Messrs. Sharman and Newton, but the Ostracoda were identified by Prof. Rupert Jones and all the sponges in Mr. Saunders' collection were named by Dr. G. J. Hinde.

The fourth column is a list of the species obtained by Mr. Hill and myself from the exposures at Preston, near Hitchin, and they have also been examined by Mr. Woods.

The remaining columns catalogue the species found by Mr. Hill and myself at localities south-east of Hitchin.

—	Boxmoor.	Dunstable and Markgate.	Luton.	Preston.	Lannock Farm.	Clothall.	Wallington.
Pisces.							
Corax falcatus, *Ag.* - - - - -	–	–	3	4	–	–	–
Oxyrhina Mantelli, *Ag.* - - - - -	–	–	3	–	–	–	–
Ptychodus mammillaris, *Ag.* - - - - -	–	–	3	–	–	6	–
,, latissimus, *Ag.* - - - - -	–	–	3	–	–		–
Vertebra of fish - - - - - - -	–	–		4	–		–
Cephalopoda.							
Ammonites [Prionocyclus] Neptuni, *Gein.* -	–	2	3	4	–	–	–
,, [Pachydiscus] peramplus, *Mant.*	1	2	3	4	–	6	–
Baculites bohemicus, *Fritsch* - - - - -	1	2	3	–	–	6	–
Crioceras ellipticum, *Mant.* - - - - -	–	–	3	4	–	–	–
Heteroceras reussianum, *d'Orb.* - - -	1	2	3	4	–	6	–
,, sp. - - - - - - - -	–	2	3	4	-	6	–
Scaphites Geinitzi, *d'Orb.* - - - -	1	2	3	4	5	6	7
Ptychoceras Smithi, *Woods* - - - -	–	–	–	–	5	–	–
Nautilus sublævigatus, *d'Orb.* - - -	1	2	3	4	–	–	–
Gasteropoda.							
Aporrhais Mantelli, *Gard.* - - - - -	–	–	3	–	–	–	–
Avellana cf Humboldti, *Müller* - - -	–	–	3	–	–	6	–
Cerithium cuckhamsliense, *Woods* - -	–	2	3	4	–	–	–
,, Saundersi, *Woods* - - -	–	–	–	4	–	6	–
Dentalium turoniense, *d'Orb.* - - -	–	–	3	–	–	–	-
Emarginula Sanctæ-Catharinæ, *Passy* - -	–	–	3	-	–	–	–
Pleurotomaria depressa, *Sow.* - - - -	–	–	3	–	5	–	–
,, perspectiva, *Mant.* - -	–	2	3	4	5	6	–
,, Thomsoni ? *Tate* - - -	–	2	3	–	–	–	–
Trochus Schlüteri, *Woods* - - - -	1	2	3	4	5	6	–
Fusus sp. (cast.) - - - - - - -	–	-	3	–	–	–	–
Solariella gemmata, *Sow.* - - - -	–	2	3	4	5	6	–
Turbo Geinitzi, *Woods* - - - -	–	–	3	4	–	6	–
Lamellibranchiata.							
Arca Galliennei, *d'Orb.* - - - - -	–	–	3	–	–	–	–
,, sp. - - - - - - - -	–	2	3	–	–	–	–
Cardita cancellata, *Woods* - - - -	1	2	3	–	–	–	–
Cyprina quadrata, *d'Orb.* - - - -	–	–	3	–	–	–	–
Inoceramus Cuvieri, *Sow.* - - - -	1	2	3	–	–	–	–
,, striatus ? *Sow.* - - - -	–	2	3	–	–	–	7
,, sp. (small) - - - - -	1	2	3	–	5	-	–

—	Boxmoor.	Dunstable and Markgate.	Luton.	Preston.	Lannock Farm.	Clothall.	Wallington.
Lima granosa, *Sow.*	–	–	–	–	5	6	–
„ Hoperi, *Sow.*	1	–	3	–	–	–	–
Modiola Cottæ, *Roem.* (see Septifer lineatus)	–	–	3	–	–	–	–
Nucula, sp.	–	2	3	4	–	–	–
Ostrea normaniana, *d'Orb.*	1	2	3	–	–	–	–
„ vesicularis, *Lam.*	–	–	–	–	5	6	–
Pecten pexatus, *Woods*	–	–	3	4	5	6	–
Plicatula Barroisi, *Peron*	–	–	3	–	–	–	–
Septifer lineatus, *Sow.*	–	–	3	–	–	–	–
Spondylus latus, *Sow.*	1	2	–	–	–	–	–
„ spinosus, *Sow.*	1	2	3	4	5	6	7
Teredo amphisbæna, *Goldf.*	–	–	3	–	–	–	–
Trapezium trapezoidalis, *Roemer*	–	2	3	–	–	–	–
Brachiopoda.							
Crania egnabergensis, *Retz.*	–	2	–	–	–	–	–
Kingena lima, *Defr.*	–	2	–	–	–	–	–
Rhynchonella Cuvieri, *d'Orb.*	–	2	3	4	–	–	–
„ plicatilis, *Sow.*	–	2	3	4	5	6	7
„ reedensis, *Eth.*	1	–	3	4	5	6	7
Terebratula carnea, *Sow.*	1	2	3	4	5	6	7
„ semiglobosa, *Sow.*	1	2	3	4	5	6	7
Terebratulina striata, *Wahl.*	–	–	–	–	–	6	–
Bryozoa.							
Biflustra carantina, *d'Orb.*	–	–	3	–	–	–	–
Cellaria inæqualis, *d'Orb.*	–	–	3	–	–	–	–
Entalophora variegata, *d'Orb.* (=virgula)	–	–	3	–	–	–	–
„ linearis ? *d'Orb.* (=echinata)	–	–	3	–	–	–	–
„ sp.	–	–	3	–	–	–	–
Eschara royana, *d'Orb.*	–	–	3	–	–	–	–
Escharinella baculina, *d'Orb.*	–	–	3	–	–	–	–
Crustacea.							
Pollicipes glaber, *Roemer*	–	–	3	–	–	–	–
Crustacean claw	–	–	3	–	–	–	-
Bairdia subdeltoidea, *Münst.*	–	2	3	–	–	–	–
„ harrisiana, *Jones*	–	2	–	–	–	–	–
Bythocypris Brownei, *Jones*	–	2	–	–	–	–	–
„ rœmeriana, *Jones*	–	2	–	–	–	–	–
„ silicula, *Jones*	–	2	3	–	–	–	–
Cythere harrisiana, *Jones*	–	2	–	–	–	–	–
Cythereis auriculata, *Corn.*	–	2	–	–	–	–	–
„ lonsdaleana, *Jones*	–	2	–	–	–	–	–
„ ornatissima, *Reuss*	–	2	3	–	–	–	–
„ quadrilatera, *Roem.*	–	2	–	–	–	–	–
„ spinicaudata, *Jones*	–	2	–	–	–	–	–
„ triplicata, *Roem.*	–	2	–	–	–	–	–
„ tuberosa, *Jones*	–	2	–	–	–	–	–
Cytheridea perforata, *Roem.*	–	2	–	–	–	–	–
Cytherella ovata, *Roem.*	–	2	3	–		–	–

—	Boxmoor.	Dunstable and Markgate.	Luton.	Preston.	Lannock Farm.	Clothall.	Wallington.
Cytherella muensteriana, *Roem.*	–	2	–	–	–	–	–
„ williamsoniana, *Jones*	–	2	3	–	–	–	–
Cytheropteron alatum, *Bosquet*	–	2	–	-	–	–	–
„ concentricum, *Reuss.*	–	2	–	–	–	–	–
„ pedatum, *Marss.*	–	2	–	–	–	–	–
„ sphenoides, *Reuss.*	–	2	–	–	–	–	–
„ umbonatum, var. acanth optera	–	2	–	–	–	–	–
Macrocypris concinna, *Jones*	–	2	–	–	–	–	–
Annelida.							
Serpula fluctuata, *Sow.*	–	–	3	–	–	–	–
„ granulata, *Sow.*	–	–	3	–	–	–	–
„ ilium, *Sow.*	–	–	3	–	–	–	–
„ plexus, *Sow.*	1	2	3	–	–	–	–
Echinodermata.							
Bourgueticrinus sp.	–	–	3	–	–	–	–
Cidaris (plate and spine)	1	–	3	–	–	–	–
Cyphosoma corollare, *Klein*	–	–	3	–	–	–	–
„ radiatum, *Sorig.*	–	–	3	–	–	–	–
Echinocorys scutatus, *Leske*	–	2	3	4	–	6	7
Goniaster sp. (ossicle)	–	–	3	–	–	–	–
Holaster planus, *Mant.*	–	–	3	4	–	6	7
Micraster corbovis, *Forbes*	–	–	–	–	–	–	7
„ Leskei, *Desm.*	1	2	3	4	5	6	7
„ præcursor, *Rowe*	–	–	3	4	5	6	7
Pentacrinus Agassizi *Hag.*	–	–	3	–	–	6	–
Actinozoa.							
Parasmilia centralis, *Mant.*	1	2	3	4	5	–	7
Spongida.							
Camerospongia campanulata, *T. Smith*	–	2	3	4	5	–	7
„ sp. nov.	–	–	3	–	–	–	–
Cephalites perforatus, *T. Smith*	–	–	3	–	–	–	–
Guettardia stellata, *Mich.*	–	–	3	–	–	–	–
Placotrema cretaceum, *Hinde*	–	–	3	–	–	–	–
Plocoscyphia convoluta, *T. Smith*	–	2	3	4	–	–	–
„ flexuosa, *Mant.*	–	–	3	–	–	–	–
„ sp.	–	2	3	–	–	–	–
Polyjerea sp.	–	–	3	–	–	–	–
Porochonia simplex, *T. Smith*	–	2	3	–	–	–	–
Tremabolites perforatus, *T. Smith*	–	–	3	–	–	–	–
Ventriculites alcyonoides, *T. Smith*	–	–	3	–	–	–	7
„ angustatus, *Roemer*	–	–	3	–	–	–	7
„ impressus, *T. Smith*	1	2	3		–	–	–
„ mammillaris, *T. Smith*	–	2	3	4	–	–	–
„ decurrens, *T. Smith*	–	–	3	4	–	–	–
„ radiatus, *Mant.*	–	2	3	–	–	–	–
Verrucocœlia tubulata, *T. Smith*	–	–	3	–	–	–	–

For the Foraminifera, see General List at end of this volume.

Zones of Micraster cortestudinarium and M. coranguinum.

There are a large number of chalk pits in the counties of Bedford Hertford, and Middlesex which neither Mr. Hill nor myself have had the opportunity of visiting, and, so far as we know, few of them have been well searched for fossils, except the pits near Rickmansworth and Watford, from which collections were made by Mr. J. Rhodes for the Geological Survey in 1888. Some notes of the chalk seen in these quarries and cuttings were taken by Mr. Rhodes, and were published in the Memoir on the "Geology of London," Vol. i. p. 77 (1889).

In that memoir it was suggested that the zone of *Micraster cortestudinarium* was exposed in some of these exposures; Mr. E. T. Newton has re-examined the Micrasters obtained from them, and confirms the existence of *M. cortestudinarium* at three places, though some of the others are more correctly referable to the *M. præcursor* of Rowe. On the other hand, the presence of *M. coranguinum* and *Galerites albogalerus* at several places leads us to think that most, if not all, are in the zone of *M. coranguinum*, for it is now known that *M. cortestudinarium* ranges into the higher zone.

The large quarry at Harefield Cement Works, about three miles S.S.W. of Rickmansworth, exposes a fine section of Chalk and Eocene, about 60 feet of each being seen; the chalk is in regular beds,with frequent layers of solid flint nodules, but fossils were not abundant. Small pits in similar chalk on the west side of the Colne yielded *Micraster præcursor* and *Galerites albogalerus* with a few other fossils.

At the north end of Harefield Park Mr. Rhodes found another fine section of chalk in a large quarry, which he estimated as 80 feet deep. The chalk of the lower 20 feet is rather harder than that above, but does not otherwise differ; layers of flints occur throughout, and many of them are cavernous, containing *Doryderma ramosum* and other sponges. There are also some tabular flints (? continuous layers of flint). The only determinable *Micraster* is referable to *præcursor.*

A quarry by the side of the canal, a mile and a half south-west of Rickmansworth, is about 60 feet deep in chalk, with many cavernous and spongiferous flints. About 40 feet above the floor an *Ostrea* (? *acutirostris*) occurred abundantly, with many fragments of a large *Inoceramus.*

At Rickmansworth, about 12 feet of chalk is exposed in the cutting by the goods yard, and in a cutting to the eastward, by Croxley Hall, a ditch by the side of the latter yielding many *Cidaris* spines and Micrasters; among the latter both *M. coranguinum* and *M. cortestudinarium* occur. *M. cortestudinarium* was also obtained from the floor of a ballast pit, two miles east of Rickmansworth.

The cutting on the railway between Watford Junction and the tunnel to the north-west shows chalk with many flints, 90 per cent. of which are hollow and spongiferous. From chalk thrown out of the shaft near the southern end of the cutting Mr. Rhodes found a few fossils and obtained some others by washing the material in the hollow flints.

A large quarry between Watford and Bushey shows chalk which is probably higher than the last; its depth is about 60 feet, the higher part being "yellow-banded chalk, pieces of which are very hard," the lower part white chalk; layers of solid flints occur throughout. The fossils include *Galerites albogalerus, Micraster coranguinum*, and *M. cortestudinarium*, all coming from the lower half of the section.

In a pit at Letchmoor Heath, south-east of Aldenham, the chalk resembles that of Bushey. In Berry Wood, west of Aldenham, there appears to be chalk like that of Watford tunnel, for Mr. J. Hopkinson describes it as "abounding in the remains of sponges, surrounded by mere shells of flint, and containing spicules, foraminifera, and even polyzoa beautifully preserved."*

North of Aldenham there are four pits, in all of which a small oyster, resembling *Ostrea acutirostris*, is the commonest fossil.

The only section in the higher part of the Upper Chalk of Hertfordshire which I have personally seen is that in a large quarry more than half a mile east of Stevenage.

When seen in 1884 this showed a face of chalk some 50 feet in depth, with an inner pit going a further distance of about 20 feet. The whole consists of soft white chalk, with frequent layers of flints, one set of nodules being of large size, but those in the lowest beds are smaller. I was informed that the well at the foreman's cottage was sunk 135 feet, and deepened by 5 feet subsequently, in a dry season, the chalk at the bottom being very hard; this was probably the Chalk Rock, so that the lowest beds seen in the quarry are 60 or 70 feet above that rock. *Terebratula carnea* is the commonest fossil, but I also obtained from the workmen *Micraster præcursor* and the gibbose variety which so closely resembles *Epiaster gibbus*.

In 1886 a well was sunk at a spot about a quarter of a mile east of Stevenage church, and the following particulars of the beds traversed were obtained by Mr. W. Hill :—

	Feet.
White Chalk with flints - - - - - - - - -	112
Chalk Rock (sample seen) - - - - - - - - -	3
White Chalk - - - - - - - - - - - -	10
	125

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* Proc. Geol. Assoc., Vol. ii. p. 44 (1871).

The following is a revised list of the fossils collected by Mr. Rhodes from the pits above described. It is also rearranged from the original lists, and the references to localities are as follow :—

1. Harefield, Harefield Park, Troy Farm, and Wheyberds.
2. Quarries south-west of Rickmansworth.
3. Quarries at and east of Rickmansworth.
4. Watford and Bushey.
5. Quarries near Aldenham.
6. Two quarries near Shenley.

	1	2	3	4	5	6
Fish remains	1	–	–	–	5	–
Lamellibranchiata.						
Inoceramus Cuvieri ? *Sow.*	–	2	–	–	–	–
„ involutus, *Sow.*	–	–	–	–	–	–
„ sp.	1	2	3	4	5	6
Ostrea acutirostris, *Nilss.*	1	2	–	–	5	6
„ normaniana, *d'Orb.*	1	–	–	–	–	–
„ sp.	1	–	–	–	5	6
Pecten cretosus, *Defr* (=nitidus, *Mant.*)	1	–	3	–	–	6
„ sp.	–	–	–	4	5	–
„ (Neithea) quinquecostatus, *Sow.*	–	–	–	–	5	–
Spondylus spinosus, *Sow.*	–	–	–	–	–	–
„ sp.	1	–	–	4	–	–
Brachiopoda.						
Crania egnabergensis, *Retz.*	–	–	–	4	5	6
„ parisiensis, *Defr.*	1	–	–	–	–	–
Kingena lima, *Defr.*	–	–	–	4	–	–
Megathyris (Argiope) megatrema, *Ag.*	–	–	–	4	–	–
Rhynchonella reedensis ? *Eth.*	–	–	–	4	5	–
„ plicatilis ? *Sow.*	–	–	–	4	5	–
Terebratula semiglobosa, *Sow.*	1	2	3	4	5	–
Terebratulina striata, *Wahl.*	1	–	3	4	–	6
Thecidium Wetherelli, *Morris*	1	–	–	–	–	–
Bryozoa.						
Actinopora (Apsendesia) diademoides, *d'Orb.*	1	–	–	–	–	–
Alecto (Stomatopora)	1	–	3	4	–	–
Bicavea dilatata, *d'Orb.*	–	–	–	4	–	–
Cellepora ?	1	–	–	–	–	–
Crisina subgracilis, *d'Orb.*	–	–	–	4	–	–
Defrancia ?	–	–	–	–	5	–
Diastopora sp.	–	2	–	4	–	–
Domopora clavula, *d'Orb.*	1	–	–	4	–	–
Entalophora clavata ? *d'Orb.* (=echinata)	–	–	–	4	–	–
„ obliqua, *d'Orb.* (=Clausa heteropora)	1	–	–	4	–	–
„ raripora, *d'Orb.*(=virgula)	–	–	–	4	–	–
Eschara sp.	–	–	–	4	–	–
Escharina sp.	1	–	3	–	–	–
Flustrellaria granulosa, *d'Orb.* (Onychosella)	–	–	–	4	–	–
Homœosolen ramulosus, *Lonsd.*	–	–	–	4	–	–
Membranipora sp.	1	–	–	4	–	–
Onychosella Lamarcki, *Hag.*	1	–	–	–	–	–

	1	2	3	4	5	6
Sparsicava carentina, *d Orb.*	–	–	–	4	–	–
Stomatopora ramea, *Blainv.*(=Prob. ramosa, *Edw.*)	1	–	–	–	–	–
Truncatula alternata, *d'Orb.*	–	–	–	4	–	–
Vincularia sp.	–	–	–	4	–	6
Annelida.						
Serpula granulata, *Sow.*	–	–	–	–	–	6
„ ilium, *Goldf.*	1	–	–	–	5	–
„ plexus, *Sow.*	–	–	–	–	–	–
„ proteus ? *Sow.*	1	–	–	4	–	–
„ sp.	1	–	–	–	–	–
Terebella lewesiensis, *Davies*	1	–	–	–	–	–
Crustacea.						
Pollicipes glaber, *Roemer*	1	–	–	–	–	–
Actinozoa.						
Caryophyllia cylindracea, *Reuss*	1	–		–	–	–
Parasmilia sp.	–	–	–	4	5	–
Echinodermata.						
Bourgueticrinus ellipticus, *Miller*	1	–	–	4	4	6
Cidaris clavigera, *König*	–	–	3	4	5	–
„ perornata, *Forbes*	1	–	3	4	–	–
„ sceptrifera, *Mant.*	1	–	3	4	–	–
„ subvesiculosa, *d'Orb.*	–	2	–	4	5	–
„ sp.	–	2	–	–	–	–
Echinocorys scutatus, *Leske*	1	2	3	4	5	–
Galerites albogalerus, *Leske*	1	–	–	4	–	–
Goniaster (ossicles)	1	–	3	–	5	6
Metopaster Parkinsoni, *Forbes*	1	–	–	–	–	–
Micraster coranguinum, *Leske*	1	–	3	4	–	–
„ cortestudinarium, *Goldf.*	–	2	3	4	–	–
„ præcursor, *Rowe*	1	–	–	–	–	–
Oreaster sp.	–	–	–	4	–	–
Pseudodiadema (Spine)	–	–	–	–	5	–
Spongida.						
Doryderma ramosum, *Mant.*	1	–	–	–	–	–
Guettardia stellata, *Mich.*	1	–	–	–	–	–
Porosphæra urceolata, *Lam.*	–	–	–	–	5	–
„ Woodwardi, *Carter*	–	2	–	–	–	–
„ sp.	1	–	–	–	–	6
Thamnospongia sp.	–	–	3	4	5	–
Ventriculites impressus, *T. Smith*	–	–	–	4	–	–
Foraminifera.						
Cristellaria rotulata, *Lam.*	–	–	–	4	–	–
Lituola nautiloides, *Defr.*	–	–	–	4	–	–

CHAPTER XVIII.

THE UPPER CHALK IN CAMBRIDGESHIRE, ESSEX, AND SUFFOLK.

Very little is yet known about the Upper Chalk of these counties, partly because they were surveyed before the value of the zonal divisions of the Chalk was understood or appreciated in England, and partly because so much of the surface of the Chalk is covered and concealed by the glacial deposits. Hence the area is not an attractive one for zonal exploration, but no doubt something might be made of it by anyone who chose to examine it specially for this purpose ; thus, the frequent layers of flints would doubtless serve to distinguish the *Micraster* zones from those of *Marsupites* and *Actinocamax quadratus* in which flints are few and scattered.

Even the outcrop of the Chalk Rock has not been followed continuously. It was not mapped at all by the Geological Survey within the area of Sheet 47, and was only followed in Sheet 51 as far as Stetchworth, but Mr. H. Woods of Cambridge has since traced it as far Higham between Newmarket and Bury St. Edmunds.*

The remarkable flexure which is disclosed by pits in the Chalk Rock near Royston has been mentioned in Vol. II. 469.

The total thickness of the Chalk at Combs, near Stowmarket, as recorded by Mr. P. Bruff from a boring made there in 1855,† is 817 feet, of which 504 feet is said to have been through "chalk with flints." In a recent boring at Stutton, near Ipswich, the Chalk was entered at 70 feet from the surface, and the base of the Middle Chalk was found at a depth of about 800 feet, so that the Upper and Middle Chalk were about 730 feet thick, and of this probably about 500 should be assigned to the Upper Chalk.

Zone of Holaster planus (Chalk Rock, etc.).

In Essex the zone of *Holaster planus* presents the same facies as in Hertfordshire, but in Cambridgeshire only the lower rock-bed remains and the upper part of the zone consists of ordinary white chalk with numerous flints and without any hard beds. This facies of the zone has a thickness of at least 25 feet.

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* Since the above was written, search for fossils has been made by the Rev. E. Hill, Mr. G. W. Hewetson and others ; the results were published in Proc. Geol. Assoc., vol. xviii, p. 85, and are incorporated in this chapter

† Proc. Inst. Civ. Eng., Vol. xix. p. 42.

Essex.—The Chalk Rock first comes within the influence of the flexure above mentioned at Therfield, a village which is really in Hertfordshire, about two miles west of Royston. Here a pit, three furlongs north of the church, exposes a few feet of soft (Middle) chalk overlain by hard compact limestone (Chalk Rock), which dips northward at about 15deg. There is another small pit, half a mile south-west of the church, which also shows the same rock, but there it is horizontal, or nearly so; from this exposure I obtained *Parasmilia centralis*, *Rhynchonella plicatilis* (large), *Terebratula semiglobosa*, *Spondylus spinosus*, and the cast of a *Turbo* (probably *Geinitzi*).

The next section is a quarry on the east side of the main road, two miles south of Royston, and a mile north of Reed. This is represented in Fig. 124, taken from a sketch by Mr. Penning.*

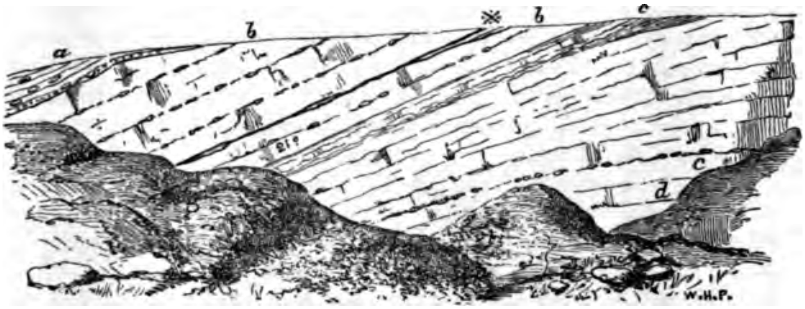

FIG. 57.—View of the Chalk-pit north of Reed.

		Feet.
a.	Boulder-clay with hard crystalline chalk beneath.	
b b.	Upper Chalk, with layers of flints, and a continuous layer or floor of flint (dipping N. at 21 deg.) at	18
c c. Chalk Rock Beds.	Hard compact cream-coloured nodular chalk with many fossils - about	2
	Rough whitish chalk with a few scattered flints in the lower part	10
	Hard nodular cream-coloured chalk	2
d.	Middle Chalk.—Firm white chalk with a sparse layer of flints at the top, curving till nearly horizontal.	

Another interesting section is shown in a pit at Newsells Bury, half a mile north of Barkway, where the anticline is more pronounced, and the beds curve over till they dip at 60° to the north. The succession here in 1877 was as follows:—

		Feet.
Upper Chalk.—Soft white chalk with scattered flints		6
Chalk Rock Beds.	Hard cream-coloured nodular limestone	2
	Rubbly whitish chalk with a thin layer of whitish marl	? 12
	Hard cream-coloured nodular rock; many fossils	2½
Firm white chalk		? 5

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* See "Geology of the N.W. part of Essex," Mem. Geol. Survey, 1878 p. 8; also H. B. Woodward, Quart. Journ. Geol. Soc., vol. lix., p. 362, and Proc. Geol. Assoc., vol. xviii., 1903.

The rock-beds are also seen at Barley (Smyth's End), where they dip north-west at about 40°, and again near Heydon, where they are dipping at about 25° a little west of north. Beyond this the flexure has not been traced.

The Chalk Rock is exposed by the roadside half a mile east of Little Chesterford, and better in a quarry S.S.E. of the farm called Great Chesterford Park, where the section recorded by Mr. Penning is as follows:—

	Feet.
5. Chalk with flints dipping slightly to S.E. - - - -	6
4. Rubbly lumps of yellowish crystalline chalk set in a marly matrix with fossils and phosphatic nodules.	2–5
3. Marly chalk - - - - - - - - - -	
2. Hard crystalline chalk, passing down into - - -	
1. Soft chalk with few flints - - - - -	10

Cambridgeshire.—North of Chesterford no good exposures were found till we reach a pit by Carleton Grange, N.N.E. of Balsham, where the Chalk Rock, about 3 feet thick, forms the roof of several tunnels which have been driven into the Middle Chalk below it.

The quarry at the Limekilns, just north-west of Balsham, is above the rock-bed, and appears to represent the upper part of the *H. planus* zone. It is about 16 feet deep, in soft white chalk, with several layers of flints, which are black inside and enclose some fossils (*Cidaris*, *Spondylus spinosus*, etc.). Mr. Allen also obtained many Micrasters, and Mr. E. T. Newton informs me that a re-examination of these shows that most of them belong to the form now called *M. Leskei*, but that one of them is a good specimen of *M. corbovis*.

There is another quarry to the northward, and half a mile north-west of West Wratting, which is in similar chalk, and this, too, has yielded *M. Leskei* and *M. præcursor*, but not *M. corbovis*.

It has also been quarried three-quarters of a mile south-west of Westley Waterless, where the following section was seen:—

	Feet.
White chalk with flints - - - - - - - - - -	8
Chalk Rock.—Compact yellowish limestone, much broken up, but upper surface clearly marked - - - about	3
White chalk with a few scattered flints.	

The next exposure is a quarry by Underwood Hall, north-west of Westley, but no Chalk Rock limestone exists here, and the characters of the chalk are so different that one would hardly suppose the beds to be on the horizon of the Chalk Rock, were it not that they are fossiliferous, and contain the same fauna. A brief note of this section was published in the "Geology of the Neighbourhood of Cambridge" (p. 68), but Mr. H. Woods has kindly supplied with me more accurate measurements, taken by him in 1899. These are as below:—

		Ft.	in.
Zone or H. planus.	White chalk with many flints in somewhat irregular layers - - - - - - -	16	3
	Lumps and discontinuous layers of very hard chalk embedded in soft chalk, with a few flints. Many fossils - - - - - - - - -	6	3
Middle Chalk.	Soft chalk with a few flints - - - - -	2	0
	Continuous layer of flint - - - - - -	0	2
	Chalk with occasional flints - - - - -	1	8
	Continuous layer of flint - - - - - -	0	3
	Soft white chalk in thick beds, with occasional flints, to floor of quarry - - - - - -	4	9
		31	4

In a pit west of Stetchworth Church the rock appears again in its normal form, and contains some of the usual fossils. It is seen at the bottom of the pit and yielded ***Micraster corbovis*, *M. Leskei*, *M. præcursor*** and ***Lima Hoperi***. Above it there is about 16 feet of chalk which contains regular horizontal layers of black flints; some of these flints, however, are of great vertical height, two feet or more, passing through one or more beds of chalk, and swelling out slightly at the planes of division.

Mr. Woods also informs me that the Chalk Rock is particularly well shown in a quarry at Wood Ditton, still further eastward, and he sends me the following particulars of the section as seen in August, 1899:—

		Feet.
Upper Chalk.	Firm white chalk with a few flints, weathering into rather thin pieces. Some phosphatic nodules occur at the very base - - - - - - - - - - - - -	10½
	Chalk Rock.—Very hard chalk with many green-coated phosphatic nodules, passing down into lumpy chalk, consisting of hard masses with softer chalk between - -	2½
Middle Chalk	Soft chalk with very few flints - - - - - -	3½
	Continuous flint-band from ½ to 1½ inches.	
	Soft chalk with rather large and fairly numerous flints; bedding well marked - - - - - seen for	9
		25½

The upper surface of the Chalk Rock is a well-marked plane. The beds dip southward at about 2° or 3°; those above the flint band are best seen on the south and south-east sides, those below it on the north side of the pit.

A pit about half-a-mile north of Cheveley shows firm white Chalk with flints, from which Mr. Woods has obtained fossils that prove it to belong to the zone of *H. planus*. *Micraster corbovis* is abundant, and with it are forms of *M. præcursor* which Dr. Rowe pronounces to be like those from the *H. planus* zone on the South Coast.

Mr. Woods also found the rock-bed exposed in a pit about a quarter of a mile west of Upper Higham, the section showing:—

	Feet.
Chalk (inaccessible) - - - - - -	3 to 4
Chalk Rock passing down into lumpy chalk - -	2½
Soft white chalk with few flints; *Holaster planus*, *Micr. corbovis*, *Spondylus spinosus* - - - -	6½
Continuous layer of flint 1 to 2 inches thick.	
Soft white chalk with flints - - - seen for	7
	About 20

The railway cutting east of Higham Station, and a large pit by the road to Bury, near by, show chalk with *Holaster placenta* and *Micraster* which were submitted to Dr. Rowe, who refers them to the upper part of the zone of *Holaster planus*.

Zone of Micraster cortestudinarium.

This zone is probably represented in some of the overlying chalk, but no exposures have been found which can be referred to it with any degree of certainty.

The chalk exposed in a small quarry near Little Saxham probably belongs to this zone; Mr. Woods found here spines of *Cidaris clavigera* and many fragments of a large *Inoceramus*.

Zone of Micraster coranguinum.

Essex. In the valley of the Cam there are several pits near Saffron Walden and Littlebury in chalk, with layers of flints.*

From the lime-kiln half a mile north of Saffron Walden the following fossils were obtained:—*Epiaster gibbus, Micraster præcursor, Cidaris serrifera, Echinocorys scutatus,* and *Inoceramus Cuvieri*, species which seem to indicate the *M. coranguinum* zone. From another pit half a mile east of the town the following were obtained from the workmen:—

Coscinopora quincuncialis.
Parasmilia centralis.
Bourgueticrinus ellipticus.
Cidaris sceptrifera.
Actinocamax? (broken).
Scapanorhynchus rhaphiodon

Cambridgeshire. The chalk near Shudy Camps has yielded *Micraster coranguinum*, and *Galerites subrotundus*,† and Mr. H. Woods informs me that *Infulaster excentricus* was also obtained by Mr. J. Carter from that locality.

The shaft and boring at the Town Waterworks of Shudy Camps are 255 feet deep, and the following information kindly supplied with me more accurate measurements, taken by him in 1899. These are as below:—

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* See Geology of the North-West part of Essex (Sh. 47), Mem. Geol. Survey, pp. 10, 11 (1878).

† See Geol. Mag. for 1891, p. 116.

		Ft.	*in.*
Zone or *H. planus.*	White chalk with many flints in somewhat irregular layers - - - - - - -	16	3
	Lumps and discontinuous layers of very hard chalk embedded in soft chalk, with a few flints. Many fossils - - - - - - - -	6	3
Middle Chalk.	Soft chalk with a few flints - - - - -	2	0
	Continuous layer of flint - - - - - -	0	2
	Chalk with occasional flints - - - - -	1	8
	Continuous layer of flint - - - - - -	0	3
	Soft white chalk in thick beds, with occasional flints, to floor of quarry - - - - - -	4	9
		31	4

In a pit west of Stetchworth Church the rock appears again in its normal form, and contains some of the usual fossils. It is seen at the bottom of the pit and yielded *Micraster corbovis*, *M. Leskei*, *M. præcursor* and *Lima Hoperi*. Above it there is about 16 feet of chalk which contains regular horizontal layers of black flints; some of these flints, however, are of great vertical height, two feet or more, passing through one or more beds of chalk, and swelling out slightly at the planes of division.

Mr. Woods also informs me that the Chalk Rock is particularly well shown in a quarry at Wood Ditton, still further eastward, and he sends me the following particulars of the section as seen in August, 1899:—

		Feet.
Upper Chalk.	Firm white chalk with a few flints, weathering into rather thin pieces. Some phosphatic nodules occur at the very base - - - - - - - - - - - -	10½
	Chalk Rock.—Very hard chalk with many green-coated phosphatic nodules, passing down into lumpy chalk, consisting of hard masses with softer chalk between - -	2½
Middle Chalk	Soft chalk with very few flints - - - - - -	3½
	Continuous flint-band from ½ to 1½ inches.	·
	Soft chalk with rather large and fairly numerous flints; bedding well marked - - - - - seen for	9
		25½

The upper surface of the Chalk Rock is a well-marked plane. The beds dip southward at about 2° or 3°; those above the flint band are best seen on the south and south-east sides, those below it on the north side of the pit.

A pit about half-a-mile north of Cheveley shows firm white Chalk with flints, from which Mr. Woods has obtained fossils that prove it to belong to the zone of *H. planus*. *Micraster corbovis* is abundant, and with it are forms of *M. præcursor* which Dr. Rowe pronounces to be like those from the *H. planus* zone on the South Coast.

Mr. Woods also found the rock-bed exposed in a pit about a quarter of a mile west of Upper Higham, the section showing:—

	Feet.
Chalk (inaccessible) - - - - - - -	3 to 4
Chalk Rock passing down into lumpy chalk - -	2½
Soft white chalk with few flints; *Holaster planus*, *Micr. corbovis*, *Spondylus spinosus* - - - - -	6½
Continuous layer of flint 1 to 2 inches thick.	
Soft white chalk with flints - - - seen for	7
	About 20

The railway cutting east of Higham Station, and a large pit by the road to Bury, near by, show chalk with *Holaster placenta* and *Micraster* which were submitted to Dr. Rowe, who refers them to the upper part of the zone of *Holaster planus*.

Zone of Micraster cortestudinarium.

This zone is probably represented in some of the overlying chalk, but no exposures have been found which can be referred to it with any degree of certainty.

The chalk exposed in a small quarry near Little Saxham probably belongs to this zone; Mr. Woods found here spines of *Cidaris clavigera* and many fragments of a large *Inoceramus*.

Zone of Micraster coranguinum.

Essex. In the valley of the Cam there are several pits near Saffron Walden and Littlebury in chalk, with layers of flints.[*]

From the lime-kiln half a mile north of Saffron Walden the following fossils were obtained:—*Epiaster gibbus*, *Micraster præcursor*, *Cidaris serrifera*, *Echinocorys scutatus*, and *Inoceramus Cuvieri*, species which seem to indicate the *M. coranguinum* zone. From another pit half a mile east of the town the following were obtained from the workmen:—

Coscinopora quincuncialis.
Parasmilia centralis.
Bourgueticrinus ellipticus.
Cidaris sceptrifera.
Actinocamax? (broken).
Scapanorhynchus rhaphiodon

Cambridgeshire. The chalk near Shudy Camps has yielded *Micraster coranguinum*, and *Galerites subrotundus*,[†] and Mr. H. Woods informs me that *Infulaster excentricus* was also obtained by Mr. J. Carter from that locality.

The shaft and boring at the Town Waterworks of Shudy Camps are 255 feet deep, and the following information respecting them is from Mr. J. Ingold, who made the well, which was dug 103 feet and bored 152 feet:—

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[*] See Geology of the North-West part of Essex (Sh. 47), Mem. Geol. Survey, pp. 10, 11 (1878).

[†] See Geol. Mag. for 1891, p. 116.

	Feet.
Loam and boulder clay	to 25
Chalk and clay	3
Chalk with flints	227
	255

Suffolk. In the south-east of Suffolk this zone is almost entirely concealed by Glacial deposits, but is exposed in several quarries near Bury St. Edmunds. I had surmised that the chalk of Bury belonged to this zone from the geographical position of the town, but had no proof of it till this year (1902), when, at my suggestion, the Rev. E. Hill, Rector of Cockfield, was kind enough to obtain fossils from one of the pits. These confirmed my surmise, and I am indebted to Dr. A. W. Rowe for his opinion as to the zonal position of the fauna obtained.

The quarry visited by Mr. Hill is south-west of the town, and the chalk is burnt for lime. Mr. Hill has furnished me with the following description of the section—the pit is about 35 feet deep, and the succession is as follows:—

	Feet.	In.
Soil and chalk-rubble	2	–
Chalk, with a few scattered flints	6	–
Flints in line, but widely separated, up to	0	6
Chalk, with a few scattered flints	6	–
Flints in line at irregular distances, up to	0	8
Chalk without flints, seen for	20	–

The flints are black inside with a thin white cortex, seldom more than $\frac{1}{8}$th of an inch thick; some of those in the lower plane are large, massive, lenticular flints, from 12 to 18 inches long. The fossils found were the following:—

Echinocorys scutatus.
Micraster coranguinum.
" " var. gibbosa.
Terebratula semiglobosa.
Thecidium Wetherelli (common).
Ostrea vesicularis.
" normaniana.
Plicatula sigillina.

Dr. Rowe, to whom the Echinoderms were sent for examination, informs me that they belong to varieties which are characteristic of the middle part of the zone of *M. coranguinum.* Some of the Micrasters are short, gibbous and conical, strongly resembling *Epiaster gibbus*, except that they possess a decided subanal fasciole; Dr. Rowe regards these as merely a variety of *M. coranguinum*, but M. Lambert includes them in his *M. senonensis* together with the non-fascioled forms usually known as *Epiaster gibbus*, considering the presence or absence of a fasciole as of small importance.

Another quarry, about a mile north-east of Bury, on the road to Ixworth, was visited by Mr. Hill, and found to show about 15 feet of chalk with two layers of flints, but no fossils were obtained.

Dr. Wheelton Hind has kindly allowed me to examine some fossils which he obtained some years ago from a chalk-pit at Pakenham, a village 4½ miles E.N.E. of Bury, and I identified the following species, which show that this locality comes within the same zone:—

Echinocorys scutatus.	Spondylus spinosus.
Micraster coranguinum.	„ latus.
Epiaster gibbus.	Plicatula sigillina.
Galerites albogalerus.	Thecidium Wetherelli.

About 1½ mile N.E. of Pakenham, and the same distance S.E. of Ixworth, on the road to Stowlangtoft, is a quarry which Mr. Hill has visited, and of which he gives me the following account—this is an extensive but shallow excavation, usually only 10 feet deep, but sometimes worked to 14 feet; from it caves are tunnelled into the chalk, and one of them is as much as 30 feet long. The chalk is very white and soft, and there are a few flints scattered irregularly through it, with a layer of flints about 10 feet from the surface; some of the latter are large and of irregular shape up to 2 feet in length. Mr. Hill found a few fossils which appear to belong to the following species, though the Echinoderms are much crushed, and I am indebted to Dr. Rowe for assistance in their identification:—

Micraster coranguinum ?	Kingena lima.
Galerites albogalerus ? (young).	Ostrea vesicularis.
Cidaris sceptrifera.	Inoceramus sp.
Scalpellum maximum.	

The test of the *Micraster* is very thin, and the beds probably belong to the highest part of the zone.

South of Fornham All Saints is a large chalk pit, of which Mr. Blake observes that it shows "about 20 feet of chalk, containing flints irregularly interspersed," and two thin continuous seams of flint, but no fossils are recorded.*

The chalk which has been in former days so largely quarried to obtain flints for the making of gun-flints at Brandon and Lingheath belongs in all probability to the zone of *Micraster coranguinum*, but though Mr. Skertchly obtained useful accounts of the succession of beds of chalk and flint proved in the excavations, he only records a single fossil from them, and that is *Echinocorys scutatus*, a species which has little zonal value.

My reasons for believing these beds to be referable to the zone of *M. coranguinum* are, (1) their position to the eastward of the outcrop of the Middle Chalk; (2) their alignment with the chalk of Bury, now known to belong to this zone; (3) the prevalence of large flints and of thick continuous floors of flint; (4) the fact that in at least one layer the flints have a banded crust. It is possible, however, that the lowest part of the series

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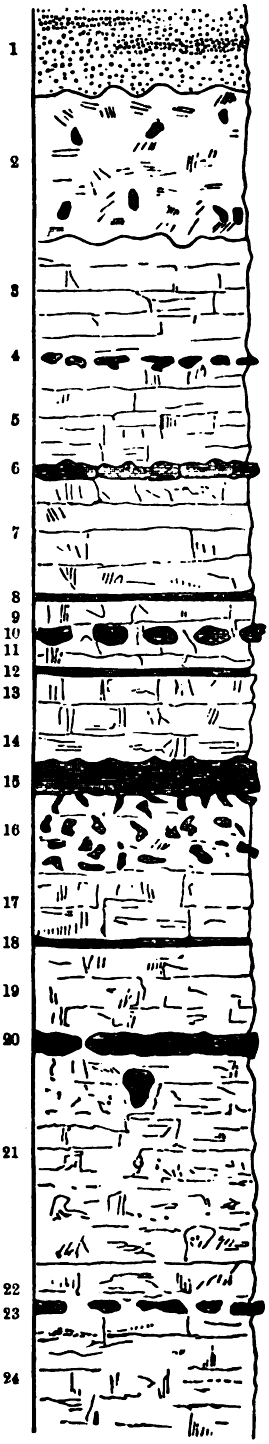
* Geology of Parts of Cambridgeshire and Suffolk (Expl. of Sh. 51 N.E., p. 47).



	Ft.	in.
1. Sand and gravel	3	0
2. "Dead lime" or reconstructed chalk, in which the flints stand edgewise or on end	5	0
3. Soft white chalk of the ordinary character	4	0
4. "Horns," an irregular layer of flints which are nearly all small and finger-shaped. The thickness is included in the following:—		
5. Soft white chalk	3	6
6. "Toppings," the first regular layer of flint almost continuous, knobby on the top, flat at the base, breaking in lengths of a foot or less	0	5
7. Soft white chalk, as before	4	0
8. First pipe-clay, or seam of marl	0	4
9. Hard, white, sub-crystalline, chalky limestone, which rings under the pick and has to be worked out from the joints		
10. "Upper Crust Flints," generally separate, round, and lumpy; nearly always grey inside; crust thick and double, often parted by a thin layer of flint. Only used as building stones	0	8
11. Soft white chalk	1	0
12. Second pipe-clay or marl seam	0	2
13. Hard white chalk, one jointless bed	1	0
14. Soft white chalk	2	0
15. "Wall Stone," a continuous floor of black flint, with "paps" or knobs above and horn-like projections below, which are sometimes a foot in length	1	0
16. Very soft chalk, so full of "horn" flints that the pick can hardly be used; often stained yellow	2	6
17. Soft white chalk	2	6
18. Third pipe clay	0	2
19. Hard white chalk	3	0
20. "Floor stone," generally continuous, but sometimes in ovoid masses, which are called "heel-pieces"; black but often grey in the middle: the bed from which the best gun-flints are made.	0	8
21. Soft white chalk, sometimes containing large flints	7	6
22. Hard white chalk	1	6
23. "Rough and Smooth Blacks;" large separate black flints in hard chalk	0	4
24. Soft white chalk.		
	45	3

FIG. 58.—Section at Lingheath, Brandon (S. B. J. Skertchly).

may belong to the zone of *M. cortestudinarium*. The account opposite is taken from published Survey Memoirs, and was obtained entirely by Mr. S. B. J. Skertchly. *

Shafts and pits for extracting flints were made on Icklingham Heath at a spot about a mile and a half north of Icklingham St. James, also at Elvedon, at Lingheath, south of Brandon, on Santon Downham Warren (east of Brandon), and at Grimes Graves (north of Brandon), the distance between the first and last locality being about 8½ miles. Throughout this district the same succession of flint beds could be recognised in every excavation; each bed of flint has its own particular characters, and was given a special name by the workmen. This general succession is shown in Fig. 124, which is that of the Lingheath Pits. They were seldom deeper than 45 feet.

Some variations of course occur in the thickness of the individual beds of chalk at different places, and consequently in the distance between one layer of flint and another, also in the size of the flints and in the thickness of the flint floors. Thus at Icklingham, according to Mr. Ashley, who worked the pits there, the "Toppings" varied from 5 to 12 inches, the "Upper Crusts" from 6 to 18 inches, the Wall Stone from 12 to 18 inches, and the floor stone from 3 to 12 inches. But the quality of each flint bed —that is to say, its texture, colour, and mode of fracture—seems to be almost invariably the same. Moreover, the three layers of marl and the bed of hard chalky limestone below the first one occur in the same order wherever they have been traversed.

Mr. Skertchly mentions that the "floor stone" was found 7 feet below the surface in sinking a well at Shakers Lodge, on Wangford Rabbit Warren, which is important as indicating the probable line of outcrop of the above series. A chalk-pit close to the lodge of Elvedon Park showed some of the above-mentioned beds in 1875, as noted by Mr. Skertchly.

	Ft.	*in.*
Sand - - - - - - - - - - - - -	0–3	0
White chalk with scattered horns flints - - - -	11	0
Pipe-clay marl - - - - - - - - - - -	0	4
White chalk - - - - - - - - - - -	3	0
Upper crust flints, large and irregular - - - -	0	8
White chalk - - - - - - - - - - -	4	6
Wall stone (flints) - - - - - - - - -	1	0
White chalk - - - - - - - - - - -	4	0

A specimen of *Echinocorys scutatus* was found here.

Zone of Marsupites.

The existence of this zone in Suffolk has only recently been proved and recorded † by means of fossils sent to me by the

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* See Geology of S.W. Norfolk and N. Cambridgeshire, being the Explanation of Sheet 65, p. 42 (1893).

† See Proc. Geol. Assoc. vol. xviii. p. 88.

Rev. E. Hill and Dr. Holden, of Sudbury. Plates of *Uintacrinus* have not yet been found, but there is good reason to believe that the lower part of the *Marsupites* zone is represented in the chalk which is quarried at and near Sudbury. One quarry to the north-east of the town is worked to a depth of about 50 feet in chalk which is white, soft, and contains very few flints; from it Dr. Holden obtained fossils which belong to the following species:—

Lamna appendiculata.
Oxyrhina sp.
Actinocamax granulatus.
„ verus.
Ostrea vesicularis.
„ semiplana.
Pecten cretosus.
Lima Hoperi.

The *Actinocamax* were sent to Dr. Rowe, who kindly wrote to the effect that the specimen of *A. granulatus*, with its scanty and somewhat feeble granulation, was such as he would expect to occur in the zone of *Marsupites* and that the example of *A. verus* was similar to those coming from the *Uintacrinus* band of that zone, in which it is a common fossil. He was consequently of opinion that the Sudbury chalk probably belonged to the band or sub-zone of *Uintacrinus*.

The probability of this reference being correct is greatly increased by the discovery of a plate of *Marsupites* at Monks Eleigh, a village about 7 miles N.E. of Sudbury. This plate was found by Mr. E. Hill, who sent me the following particulars: The chalk pit from which the fossils came is in " Back Lane " on the south side of the brook; it has a face about 8 feet high and 20 feet long, and the chalk is soft, white and damp; the only flints visible were one or two isolated nodules; fossils are very scarce and the only organisms found beside the single plate of *Marsupites testudinarius* were a small *Ostrea*, fragments of *Inoceramus* and *Porosphæra globularis*.

From Monks Eleigh the outcrop of the *Marsupites* zone probably runs northward by Brettenham, Felsham and Elmswell, but that district is deeply covered with Glacial beds, so that no evidence is obtainable. Further north, however, the chalk comes to the surface again in places, and it has been quarried near Wattisfield and Botesdale. No fossils have yet been recorded from these pits, and the only information I have been able to obtain is that published in the Survey Memoir on the country round Diss, Eye, &c. (Explanation of Sheet 50 N.W.), from which the following is quoted:—

" Chalk is shown in the valley at Wattisfield and Botesdale. About 1¼ miles north-west of Wattisfield Church is a pit showing 8 feet of soft marly chalk, with few flints. . . . At Botesdale, west of Broom Hills Farm, is a pit showing 14 feet of soft chalk, with a few flints. . . . Due north of the church, and close by the road, is a large chalk-pit, showing 20 feet of marly and rubbly chalk, overlaid by patches of gravel. A layer of flints in the lower half of the pit showed a local anticlinal disturbance, the flint line being bent up on one side to an angle of 45°.

"Near Hinderclay, one mile west of Rickinghall Inferior Church, a large pit showed 50 feet of soft rubbly chalk, with few flints, and with a line [seam] of tabular flint slightly undulating."

At Diss a deep boring was made at Mr. Taylor's brewery in 1834. Of this two accounts exist, both of which are given in the Memoir above quoted (pp. 23 and 24). They do not differ much, and I quote below the one which seems most probable; this is the account communicated to Samuel Woodward, of Norwich.

	Feet.
Blue clay with shells	50
Sand and gravel	50
Chalk nearly white without flints	80
White chalk with layers of flints	350
Grey chalk with layers of white chalk	60
Blue clay with chalk stones	25
	615

In the other account 100 feet is assigned to the white chalk without flints, which is described as soft and marly; this may possibly belong to the zone of *Marsupites*, as long ago suggested by Dr. Ch. Barrois (Recherches, p. 166). The "chalk with flints" would then include the zones of *Micraster coranguinum*, *M. cortestudinarium*, *Holaster planus*, and *Terebratulina*. The grey chalk probably represents the zone of *Rhynchonella Cuvieri*. Respecting the blue clay, Dr. S. Woodward has left a note that "from the specimen this appeared to be Chalk Marl," but this specimen may have come from the Belemnite Marl at the top of the Lower Chalk.

Zone of Actinocamax quadratus.

The most westerly pit in the South of Suffolk which can be referred with any probability to this zone is at Nedging near Bildeston and two miles east of Monks Eleigh. This was visited by Mr. E. Hill who found and sent me a well-granulated specimen of *Actinocamax granulatus*, stating that the pit is over 20 feet deep and that no flints were visible in the exposed face but a few were lying on the floor of the pit. The only other fossils obtained were *Ostrea acutirostris* and *Bourgueticrinus* sp. (cylindrical). The chalk here must be on the confines of the *Marsupites* and *Act. quadratus* zones.

In the valley of the Gipping, near Needham Market, there is also chalk with very few flints, and as *Actinocamax granulatus* has been found at one locality, the chalk here doubtless belongs to the zone characterised by that species. The following notes are reprinted from the Geological Survey Memoir on the "Geology of the Neighbourhood of Stowmarket," and are by Messrs. J. H. Blake and F. J. Bennett.

" Barking chalk-pit, south of Needham Market, is a large quarry. There are hardly any flints to be seen in the chalk here." The following fossils were found by Mr. Blake and named by Mr. Etheridge :—

Actinocamax granulatus.
Inoceramus mytiloides ?
„ (larger sp.).
Ostrea acutirostris.
Retepora ?

" The large chalk-pit about half a mile south east of Offton Church shows about 50 feet of marly, blocky chalk, rather soft, with few flints, and dipping slightly north-eastward."

There are other pits in similar chalk near Little Blakenham.

" Coddenham chalk-pits, a mile N.N.W. of the church, give fine sections, and Mr. Blake got a few fossils here." These were identified by Mr. Etheridge as *Avicula* sp., *Ostrea acutirostris ?*, *O. normaniana*, *O. semiplana*, and *Terebratula semiglobosa*.

There is " a large chalk pit on the high road south-west of Claydon Church," which Mr. Whitaker describes as showing " bedded chalk, almost flintless, 50 feet or more," and containing " small species of *Ostrea*, as at Needham Market."

About two miles further south, at Bramford, is another large quarry, for particulars of which I am indebted to Mr. G. H. Hewetson, of Ipswich ; this quarry on its eastern side presents a face of about 130 feet in height; the chalk is white where not stained yellow by infiltrated colouring matter; it is soft but firm, and is without flints except for one layer about 110 feet from the surface. Many fossils have been obtained from this quarry by the members of the Ipswich Scientific Society, and those sent to me for identification were the following :—

Lamna appendiculata.
Belemnitella lanceolata ?
Actinocamax granulatus.
Ostrea curvirostris.
„ normaniana.
„ vesicularis.
Pecten cretosus.
Spondylus lacus.
Inoceramus sp.
Serpula sp. (5-angled).
Echinocorys scutatus.
Offaster pillula.
Cœlosmilia granulata.

Mr. R. M. Brydone has also collected from Bramford and has kindly sent me a note of some additional species which are incorporated in the list on p. 247.

Zone of Belemnitella Mucronata.

No good evidence of the existence of this zone in Essex or in Suffolk is yet forthcoming. In the explanation of Sheet 47 of the Geological Survey Map (p. 22) it is stated that *Bel. mucronata* occurs in the chalk below the Reading Beds at Bishops Stortford, but this requires confirmation ; it may have been *Actinocamax granulatus*, which has elsewhere been mistaken for *Bel. mucronata*.

It is very likely that this zone does occur beneath the Drift and Crag to the east of Debenham (in Sheet 50 S.E.), but there are very few exposures in that district, the only one noted in the Survey Memoir on that sheet being an old pit at King's Hill, south of Earl Soham. At Easton Park a boring made in 1873 is said to have found chalk at 100 feet from the surface, and to have been carried to a total depth of 550 feet, but no particulars respecting the chalk are preserved (*op. cit.* p. 50).

FOSSILS FROM THE UPPER CHALK OF CAMBRIDGE, ESSEX AND SUFFOLK.

The following list of fossils from these counties has been compiled partly from the lists given in the Memoirs of the Geological Survey, but mainly from the paper referred to on p. 235. The first column includes species found in the Chalk Rock Beds; the second those from the higher part of the *H. planus* zone in Cambridge and Suffolk. The letter e=Essex, c=Cambridgeshire, s=Suffolk.

—	Zone of Hol. planus.		Zone of Micraster cortestudinarium.	Zone of Micraster coranguinum.	Zone of Marsupites.	Zone of Actinocamax quadratus.
	Chalk Rock.	Higher Beds.				
Pisces.						
Cimolichthys lewesiensis, *Leidy*	–	–	–	s	–	–
Lamna appendiculata, *Ag.*	–	–	–	e	s	s
Oxyrhina sp.	–	–	–	–	s	–
Protosphyræna ferox, *Leidy*	e	–	–	e	–	–
Scapanorhynchus rhaphiodon, *Ag.*	–	–	–	e	–	–
Cephalopoda.						
Am. [Pachydiscus] peramplus, *Mant.*	c c	–	–	–	–	–
Aptychus leptophyllus, *Sharpe*	–	–	–	–	–	s
Crioceras ellipticum, *Mant.*	c	–	–	–	–	–
Scaphites Geinitzi, *d'Orb.*	e c	–	–	–	–	–
Nautilus sublævigatus, *d'Orb.*	c	–	–	–	–	–
Actinocamax granulatus, *Blainv.*	–	–	–	e	s	s
" verus, *Miller*	–	–	–	–	s	–
Belemnitella lanceolata, *Schloth.*	–	–	–	–	–	s
" mucronata, *Schloth.*	–	–	–	–	–	s
Gasteropoda.						
Avellana of Humboldti, *Müller*	c	–	–	–	–	–
Natica vulgaris, *Reuss*	c	–	–	–	–	–
Pleurotomaria perspectiva, *Mant.*	c c	–	–	–	–	–
Solariella gemmata, *Sow.*	c c	–	–	–	–	–
Trochus (Cirrus) striatus, *Woodw.*	–	–	–	s	–	–
" Schlüteri, *Woods*	e c	–	–	–	–	–
Lamellibranchiata.						
Avicula sp.	–	–	–	–	–	s
Cardita cancellata, *Woods*	c	–	–	–	–	–
Inoceramus Cuvieri, *Sow.*	e c	c	–	e	–	–
" sp. (like mytiloides, *Sow.*)	–	–	–	–	–	s
" sp. (small)	e c	–	–	–	–	–
Lima Hoperi, *Sow.*	c	c	–	e	s	–
" pectinata, *d'Orb.*	–	–	–	–	–	s
Ostrea acutirostris, *Nilss.*	–	–	–	–	–	s
" curvirostris, *Nilss.*	–	–	–	–	–	s
" hippopodium, *d'Orb.*	–	c	–	–	–	–
" normaniana, *d'Orb.*	–	–	–	–	–	s
" semiplana, *Sow.*	c	–	–	–	s	s
" vesicularis, *Sow.*	–	–	–	s	s	s
Pecten cretosus, *Defr.*	–	–	–	–	s	–
" pexatus, *Woods*	c	–	–	–	–	–
" (Neithea) 5-costatus, *Sow.*	–	–	–	–	–	–
Pinna decussata, *Goldf.*	–	c	–	–	–	–
Plicatula sigillina, *Woodw.*	–	c	–	s	–	s
Septifer lineatus, *Sow.*	c	–	–	–	–	–

——	Zone of Hol. planus.		Zone of Micraster cortestudinarium.	Zone of Micraster coranguinum.	Zone of Marsupites.	Zone of Actinocamax quadratus.
	Chalk Rock.	Higher Beds.				
Spondylus latus, *Sow.*	e c	c	–	s	–	s
,, spinosus, *Sow.*	e c	c s	–	s	–	–
Trapezium trapezoidalis, *Roemer*	e	–	–	–	–	–
Brachiopoda.						
Crania parisiensis, *Defr.*	–	–	–	–	–	s
Kingena lima, *Defr.*	–	–	–	s	–	–
Rhynchonella plicatilis, *Sow.*	e c	c	–	–	–	–
,, reedensis, *Eth.*	e c	–	–	–	–	–
Terebratula carnea, *Sow.*	e c	c	–	–	–	–
,, semiglobosa, *Sow.*	e c	c s	–	s	–	s
,, sexradiata	–	–	–	–	–	s
Terebratulina gracilis ? *Schloth.* (var.)	–	c	–	–	–	–
,, striata, *Wahl.*	–	c	–	–	–	–
Thecidium Wetherelli, *Dav.*	–	–	–	s	–	–
Bryozoa.						
Diastopora congesta, *d'Orb.*	–	c	–	–	–	–
Domopora clavula ? *d'Orb.*	–	c	–	–	–	–
Retepora ?	–	–	–	–	–	s
Membranipora sp.	–	c	–	–	–	–
Echinodermata.						
Bourgueticrinus ellipticus, *Müller*	–	–	–	e s	s	s
Cardiaster ananchytis, *Leske*	c	–	–	–	–	–
Cidaris clavigera, *König*	–	–	s	–	–	–
,, sceptrifera, *Mant.*	–	c	–	e s	–	s
,, serrifera, *Forbes*	–	–	–	e s	–	–
,, vesiculosa, *Goldf.*	–	c	–	–	–	–
,, sp. (spine)	e	–	–	–	–	–
Cyphosoma radiatum, *Sorig.*	–	c	–	–	–	–
Echinocorys scutatus, *Leske*	e c	c	–	e s	–	s
Epiaster gibbus, *Lam.*	–	–	–	e s	–	–
Galerites albogalerus, *Leske*	–	–	–	s	–	–
Holaster planus, *Mant.*	e c	s	–	–	–	–
,, placenta, *Ag.*	–	s	–	–	–	–
Infulaster excentricus, *Rose*	–	–	–	c	–	–
Marsupites testudinarius, *Schloth.*	–	–	–	–	s	–
Micraster corbovis, *Forbes*	c	c s	–	–	–	–
,, coranguinum, *Leske*	–	–	–	c s	–	s
,, ,, var. gibbosa	–	–	–	s	–	–
,, Leskei, *Desm.*	e c	c	–	–	–	–
,, præcursor, *Rowe*	e c	c s	–	e s	–	–
Offaster pillula, *Lam.*	–	–	–	–	–	s
Crustacea.						
Scalpellum maximum *Darw.*	–	–	–	s	–	–
Annelida.						
Serpula (convolute sp.)	–	–	–	s	–	–
,, canteriata, *Hag.*	–	–	–	–	–	s
Actinozoa.						
Cœlosmilia granulata, *Dunc.*	–	–	–	–	–	s
Parasmilia centralis, *Mant.*	e c	–	–	e	–	–
Spongida.						
Camerospongia campanulata, *T. Smith*	c	–	–	–	–	–
,, subrotunda, *T. Smith*	c	–	–	–	–	–
Coscinopora quincuncialis, *T. Smith*	c	–	–	e	–	–
Etheridgea (sponge allied to)	e	–	–	–	–	–
Guettardia stellata, *Mich.*	e	–	–	–	–	–
Porochonia simplex, *T. Smith*	e	–	–	–	–	–
Porosphæra globularis, *Phil.*	–	c	–	e	s	–
Ventriculites impressus, *T. Smith*	e	–	–	–	–	–
,, mammillaris, *T. Smith*	e	–	–	–	–	–
,, radiatus, *Mant.*	e	–	–	–	–	–

CHAPTER XIX.

THE UPPER CHALK IN NORFOLK.

General Description.

The Upper Chalk of Norfolk has been much more thoroughly explored than that of Suffolk. Several active geologists lived at and near Norwich during the first half of this century, and one of them (Samuel Woodward) published in 1883 " An Outline of the Geology of Norfolk," in which he divided the formation into four parts, namely, (1) Upper Chalk with many flints; (2) Medial Chalk, with few flints; (3) Lower Chalk without flints; (4) Chalk Marl; and at the same time he showed on a small geological map the extent of ground occupied by each of these several divisions.

C. B. Rose (1835-1869) followed in S. Woodward's footsteps, and always maintained the propriety of the arrangement into Lower, Medial, and Upper Chalk, pointing out that certain fossils are characteristic of each division.* From the descriptions given it is clear that their Upper Chalk included all the chalk in which Belemnites are common, *i.e.*, the zones of *Ostrea lunata, Bel. mucronata, Act. quadratus* and *Marsupites*. The chalk of the *M. coranguinum* zone—that in which many *Inocerami* and the two species of *Infulaster* occur is referred to the " Medial Chalk," and it is correctly stated that in this division, which includes all the rest of the chalk with flints, *Belemnites and Ammonites* are rare.

Dr. Barrois explored the northern border of Norfolk in 1875, and identified the same zones there which he had recognised in other parts of the county.† The Geological Survey of the county was begun in 1875, and completed in 1883, and Mr. W. Hill subsequently examined the chalk of West Norfolk; memoirs explanatory of all the sheets, which include parts of Norfolk, have been published. Moreover, the fossil collector of the Survey (Mr. Rhodes) has at different times collected from various horizons in the chalk, both in western and central Norfolk. The consequence is that a fairly complete account of the Norfolk Chalk can now be given, and the course of some of the zones can be roughly indicated (see map Fig. 59).

One interesting feature in the Chalk of this county is that beds are exposed near Trimingham which appear to be comparable with the chalk of Maestricht, in Belgium, and of Rügen, in

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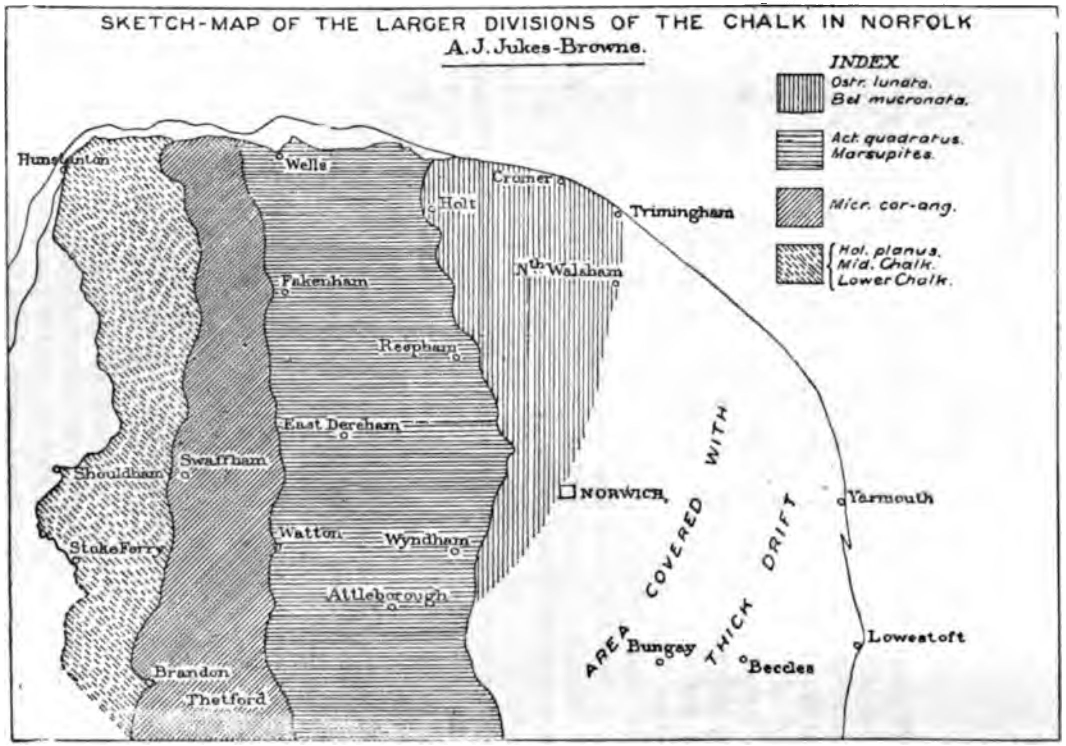
* See Geol. Mag., Vol. iv., p. 30 (1867).

† See Recherches sur le Terr. Crét. Sup., p. 156 (1876).

FIG. 59.



N.B.—The western boundary of the zone of *M. coranguinum* may have been taken a little too far to the west near Brandon and Swaffham.

The scale of the map is about 12 miles to an inch.

Pomerania, and are thus higher and newer than any other chalk in England.

With regard to the thickness of the Upper Chalk and of the Chalk as a whole in Norfolk, data for a rough calculation are afforded by two deep borings, one made at Norwich in 1868, and one at Holkham Hall in 1867. The accounts which have been given of these borings differ in some particulars, but the following are those generally regarded as most trustworthy :—

Boring at Norwich.	*Feet.*
Alluvium	12
Chalk with flints at distances of 6 or 7 feet apart	500
Soft chalk of a rusty colour	10
Harder chalk with flints as above	190
Hard chalk with flints about about 4 feet apart	350
Chalk without flints	102
Greensand and Gault (base not reached)	42
	1,206

Boring at Holkham Hall	*Feet.*
Gravel	20
Chalk with flints, the last of three masses of flint, each 3 to 4 feet thick, at a depth of 510 feet	519
Chalk without flints	116
Red marl [=" Red Chalk "]	8
Blue gault	10
Sandstone and sand	70
Stiff clay, touched	—
	743

The total thickness of chalk proved in the Norwich boring is 1,152 feet, but as the boring was at the level of the river alluvium, and the chalk rises to about 40 feet above it, the total thickness at Norwich is 1,192 feet.* Again, the Trimingham chalk being newer than any at Norwich, and its thickness at Mundesley being probably over 100 feet, a further addition must be made for it, bringing the total up to 1,292, or in round numbers 1,300 feet, as the probable thickness below eastern Norfolk.

With respect to the thicknesses of the several zones the Holkham boring gives us some assistance. In it the 116 feet of chalk without flints must include the Lower Chalk (? 56 feet), the zone of *Rhynchonella Cuvieri* (? 40 feet), and a little of the *Terebratulina* zone (20 feet). Probably another 90 feet may be assigned to the zones of *Terebratulina* and *Hol. planus.* This accounts for 206 feet out of a total of 635, but as the boring commences in the *Marsupites* zone, the upper 70 or 80 feet probably belongs to that zone, leaving about 350 for the *Micraster* zones that intervene.

In the Norwich boring the total thickness of the chalk containing flints is said to be 1,050 feet; if we assume that 440 feet of this belongs to the *Terebratulina, H. planus* and *Micraster* zones, we have 610 feet left to represent the zones of *Marsupites, Actinocamax quadratus* and *Belemnitella mucronata,* to which 40 feet must be added for chalk above the level of the river. Taking

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* H. B. Woodward, Geology of Norwich, Mem. Geol. Survey, p. 9.

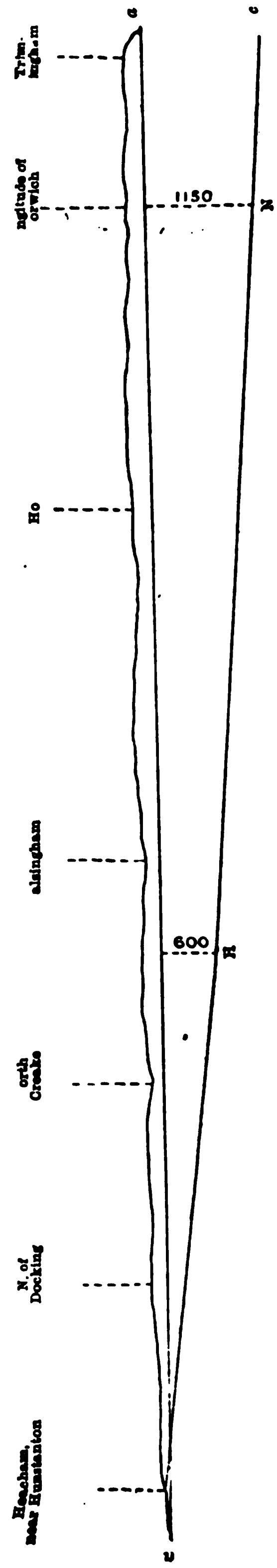

Fig. 60.—Section across the North of Norfolk from Heacham to Trimingham, to show the easterly dip of the Chalk, the line *c c* being its base and the line *a a* the approximate level of the sea.

Horizontal scale, 5 miles to 1 inch. Vertical scale, about 2,000 feet to an inch.

H represents the longitude of the Holkham boring, and N. that of Norwich.

all things into consideration we may venture on the following approximate thicknesses:—

	Feet.
Zone of Ostrea lunata	110
Zone of Belemnitella mucronata	250
Zones of Act. quadratus and Marsupites	400
Zones of M. coranguinum and M. cortestudinarium	340
Zone of Holaster planus	60
Middle and Lower Chalk	150*
	1,290

We have here included the whole of the zone of *Holaster planus* in the Upper Chalk, thus making its thickness 1,140 feet, but as stated in Volume II. p. 473 it is possible that some of the *H. planus* chalk really belongs to the Middle division, and there is at present no definite base line to the Upper Chalk of Norfolk.

STRATIGRAPHICAL DETAILS.

Zone of Holaster planus.

Only one section of this zone has been seen in the southern part of Norfolk; this is in the cutting on the railway which commences about 2 miles west of Swaffham Station; the locality was visited by Messrs. W. Hill and W. Whitaker in 1886,† and subsequently by the former alone in 1897; the following account of it is from Mr. Hill's later notes:—

At the western end of the cutting white chalk with greyish-black flints and containing *Holaster planus* is exposed for some 50 yards, dipping gently to the eastward. Near the eastern bridge a layer of large grey-black flints comes in, and about 2½ feet above this there is a bed of hard semi-crystalline creamy-white chalk, about 10 inches thick, lumpy or nodular at the top, and overlain by 4 inches of very marly, buff-coloured chalk. The hard bed contains a fair number of fossils, and the following were found by Messrs. Hill and Whitaker:—

Lamna (tooth).
Inoceramus (fragments).
Rhynchonella plicatilis (large).
„ reedensis.
Terebratula carnea.
Terebratula semiglobosa.
Holaster planus.
Micraster sp.
Cidaris (spines).
Cyphosoma radiatum.

Thus both in its lithological characters and in its fossils this bed resembles the Chalk Rock, but it does not contain glauconite nor any green-coated nodules.

The marly chalk is succeeded by white chalk with flints, and in this *Echinocorys scutatus* occurs, but was not found below.

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* The 102 feet of chalk without flints below Norwich is less than would be expected from the thickness of such chalk at the outcrop near Marham, where there must be at least 130 feet, but it is quite possible that the Lower and Middle Chalk become thinner toward the west.

† See Geology of South-Western Norfolk, etc., Mem. Geol. Survey, p. 39, (1893).

Micraster coranguinum and *Inoceramus*; from the second Mr. Rhodes collected *Inoceramus involutus, In. Lamarcki, Pecten cretosus*, and a *Spondylus*.

A little further north, and less than a mile west of Ashill, Mr. J. H. Blake found a large pit showing 30 feet of bedded chalk with layers of flint nodules. A few fossils were found here by Mr. Rhodes, viz., *Coscinopora quincuncialis, Parasmilia centralis*, a *Cidaris* spine, and *Inoceramus* (*cf. Brongniarti*).*

Swaffham has long been known as a locality for Chalk fossils, and lists were published by S. Woodward and C. B. Rose, but no careful collecting has been done there in recent years.

R. C. Taylor has remarked† that the disposition of the flints in the Swaffham chalk is peculiar, "two layers forming a pair being set at a distance of a foot apart and each pair at the distance of several feet from the next pair." Mr. Rose also remarked on the great size of the tabular flints, "many of them 8 or more feet in length and from 9 to 12 inches in thickness."‡ As these observations do not apply to the chalk in the quarry seen by Mr. Hill west of Swaffham Station, they must refer to that exposed in some of the old pits, of which there are many to the south and west of Swaffham. There are also old quarries near Castle Acre, four miles to the north, and at the Lexhams.

Litcham, about seven miles north-east of Swaffham, is another place where chalk has been quarried, and from which C. B. Rose obtained fossils. A quarry was still worked here in 1883 to the north-east of the church, and showed about 25 feet of chalk with 5 or 6 layers of black flint nodules and a few large irregular-shaped flints.§ There is another quarry about half a mile S.S.W. of Litcham, in which a few fossils were found by Mr. Rhodes.

To the north of Litcham, Lexham, and Rougham the Chalk is deeply covered by Boulder Clay, and little of it is again seen till we come to the valley of the Creake River. Here at South Creake there is a pit over 20 feet deep in rather hard chalk with layers of flints which are dark greyish-black inside. This pit has been visited by Prof. Barrois and by Mr. W. Hill, who both refer it to the zone of *Micraster coranguinum*. Mr. Rhodes has also collected from it and the neighbouring pits, and the fossils obtained are included in the list on p. 265.

The pits at Burnham Overy, north of the church, and east of Burnham Thorpe, are in the same beds, but fossils are less common.

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*Geology of the Country around East Dereham p. 11 (1888).

† Trans. Geol. Soc., Ser. 2, Vol. i. p. 378 (1824).

‡ Phil. Mag., Ser. 2, Vol. vii. p. 370 (1835).

§ See note by H. B. Woodward in the Geology of the Country around East Dereham, Mem. Geol. Survey p. 10 (1888).

2. Zones of Marsupites and Actinocamax quadratus.

These zones cannot be separated in Norfolk without more careful exploration than has hitherto been bestowed upon them, but Belemnites identified as *Actinocamax granulatus* and *Act. quadratus* occur throughout a considerable thickness of chalk. This chalk enters Norfolk between Brettenham and Diss, and runs northward in a broad band to the west of Wymondham, Reepham, and Holt (see Map, Fig. 59.)

Mr. Bennett* notes that a large pit north-west of Bridgeham shows 20 feet of soft thin-bedded chalk with a few flints, and that

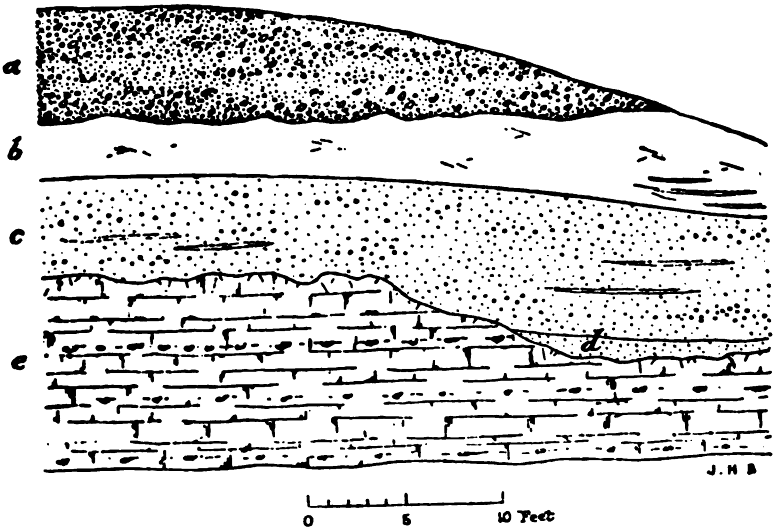

Fig. 61.—Section in a Quarry south-west of Ringland Church.

Glacial eds. { a. Gravel and sand.
b. Brown stony loam.
Pebbly Series. { c. Ash-coloured pebbly sand.
d. Orange-coloured sand.
Chalk. = e. Soft white chalk with some flints.

Mr. Rhodes obtained a few fossils from it, including a Belemnite (*Act. verus?*). In another pit, one mile W.S.W. of Banham, he saw "15 feet of soft rubbly chalk with flints," and from this Mr. Rhodes obtained *Actinocamax granulatus* and other fossils.

To the northward, within the area comprised by sheet 66 N.W., there are many exposures of chalk containing *Actinocamax* which are either *A. granulatus* or *A. quadratus*, and the pits have been described by the late Mr. J. H. Blake, in a memoir on the country round East Dereham (1888). From this memoir the following general account has been compiled :—

Near Ringland there are five or six pits which expose chalk beneath a variable thickness of pebbly sands and glacial drift. Fig. 61 represent sone of these, south-west of the church. Another, N.N.E. of the church, shows 18 feet of chalk, and there is also a good section half a mile south of the church. In all the chalk is soft, and contains a fair number of flints, black inside, of very irregular shapes and irregularly distributed, seldom along lines of bedding. *Act. granulatus*, *Rhynchonella limbata*, and other fossils were collected by Mr. Rhodes.

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*Geology of the Country around Attleborough, Mem. Geol. Survey, p. 4 (1884).

Similar chalk with *Act. granulatus* is seen in a pit over half a mile south-east of Lyng, and also half a mile north of Swanton Morley. In the latter 12 to 17 feet of chalk is shown, "soft, thinly-bedded, and containing very irregular-shaped black flints with white coating (one 20 inches long and 4 thick), also lumps of iron pyrites from 3 to 4 inches in diameter."[1]

Chalk of the same description is found near Attlebridge, Swannington, Alderford, Great Witchingham, Sparham, Banbury and Billingford. The chalk seen in the pits at these places is described by Mr. Blake in similar terms, flints always occurring, but generally scattered, and if in lines with intervals between the nodules, so that they are much less numerous than in the zone of *M. coranguinum* to the westward. Specimens of *Actinocamax* which appear to be *A. quadratus* were found at most of the places above mentioned, with *Ostrea acutirostris* at Billingford, but no plates of *Marsupites* were found at any locality in this district.

Chalk with the same lithological and palæontological characters passes northward through the area comprised within sheets 68 S.W. and 68 N.W., and has been described by Mr. H. B. Woodward. From his memoir* the following passages are taken :

At Guist and Bintree, west of Foulsham, there are pits showing soft chalk with a few scattered flints, and at both places Mr. Rhodes found many specimens of *Actinocomax granulatus* and an oyster-bed full of *Ostrea acutirostris*.

At Houghton-in-the-Dale the chalk is comparatively hard, and in the limekiln pit Mr. Rhodes found an oyster-bed with *O. acutirostris* at about 10 feet from the surface, as well as *Act. granulatus* and many plates of *Marsupites*. *Marsupites* were also found in a pit at Thorpland associated with *Act. granulatus*, *Avicula* sp. and *Echinocorys*.

Near Wells there are several exposures both in pits and in the railway cuttings in firm chalk with the usual flints and some small spherical flints containing sponge remains, which have been identified by Dr. G. J. Hinde as *Plinthosella squamosa*. This chalk was identified by Dr. Barrois in 1876 as belonging to his zone of *Marsupites*, and though he did not find that fossil he obtained *Act. quadratus*, *Inoceramus lingua*, and some others.

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* Geology of the Country Round Fakenham, Wells and Holt, Mem. Geol. Survey, pp. 5–10, (1884).

I also visited Wells in 1875, and found the chalk worked in a quarry by the railway, three quarters of a mile south-east of the station, rising in places to the surface but trenched elsewhere by hollows filled with drift. In another pit to the south-east 25 feet of chalk was shown with courses of nodular flints at distances of 6 or 8 feet apart, and with a thin continuous seam of flint; a seam of grey marl about two inches thick occurred about 15 feet from the surface; bedding horizontal. From this pit Mr. Rhodes obtained Belemnites which have been identified as *Belemnitella mucronata* and *Actinocamax quadratus ?*

A pit at the north-west end of the town (Bases Lane) showed rather lumpy chalk, with indistinct bedding, a continuous seam of flint and scattered flint nodules. I obtained *Act. granulatus ? Echinocorys scutatus*, and an *Inoceramus*, but fossils were rather scarce at both localities.

At Holkham a pit and a railway cutting have yielded *Act. quadratus ?*, *Ostrea acutirostris* and *O. vesicularis*.

Chalk is exposed at and near Stiffkey, three miles east of Wells, but no fossils were found.

Zone of Belemnitella mucronata.

The chalk of this zone is only exposed here and there along the course of the valleys which traverse the eastern part of the county, being for the most part covered by the Crag and Drift Deposits.

It was formerly much quarried near Norwich, and many fossils were obtained by a former generation of geologists, notably by S. Woodward, the author of "An Outline of the Geology of Norfolk (1833)." The following account is taken chiefly from the Memoir on the Geology of the country around Norwich by Mr. H. B. Woodward (grandson of S. Woodward).

The chalk near Norwich is soft and white with a clean and even fracture, splitting into long wedge-shaped or lenticular beds along planes which appear to be nearly horizontal joints rather than planes of original bedding. Flint nodules occur at irregular intervals, but generally in lines which seem to mark out the true stratification of the chalk. Besides these layers of flint nodules, which occur at varying intervals of from 2 to 6 feet apart, there are also some very large flints known as pot-stones or "paramoudras"; these are rudely cylindrical or cup-shaped with a central cavity, they are often 2 or 3 feet in height with a width of 1 or 2 feet, but some have been found over 6 feet high; they generally occupy a vertical position and occur both in and between the layers of ordinary flints.

Many fissures and fractures occur in the chalk, and sometimes it is locally bent into curves and flexures which have been attributed to the forcible impact of ice.

In the valley of the Yare the chalk is not exposed further east than Postwick and Surlingham. In the valley of the Bure it appears as an inlier extending from Aylsham to Wroxham. On the northern coast it is exposed from Weybourn to Runton, and thence at intervals on the shore to Cromer. Mr. C. Reid writes :—" Between Weybourn and Cromer the chalk is soft with many flints, in fact, at Runton flints are so abundant that on the foreshore they often form a nearly continuous reticulated pavement . . . . . From Old Hithe to Cromer paramoudras are common, and there are [also] numerous rings of flint, commonly 3 to 6 feet in diameter, often containing smaller rings, with sometimes a paramoudra in the centre (see Fig. 62).

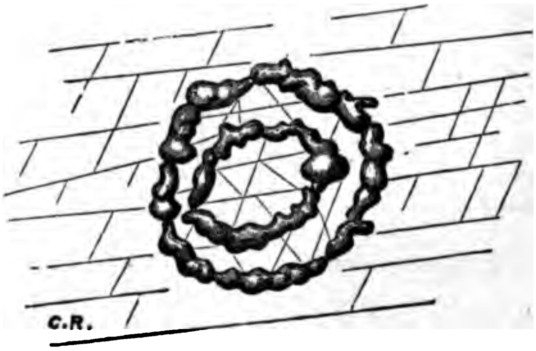

FIG. 62.—Plan of Flint-rings on the foreshore at Runton.
Scale, 2 feet to an inch.

" Perfect circles were measured up to 9 feet across, and one irregular oval was 15 feet . . . They are mere shallow rings about 10 inches or a foot in depth and not sections of cups, for when traced downward they never show a cup-shape or any tendency to a narrowing of the circle. Though sponges are very abundant no definite connection can be traced between the shape of the sponge and that of the ring or paramoudra, for irregular sponges appear to occur indifferently in the chalk or in flint.

" Fossils, except sponges, are not very plentiful, though *Belemnitella mucronata* and fragments of *Inoceramus* are common . . . From the general character of the chalk it appears to correspond with that of Norwich, but the fossils have yet to be collected and compared."*

Mr. Brydone informs me that the chalk at West Runton contains many fossils, *Echinocorys scutatus* being common, and bearing many Bryozoa, including *Homalostega pavonia*. He thinks this chalk may lie in a syncline, and be nearer the zone of *O. lunata* than that seen at Cromer.

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* The Geology of the Country Around Cromer, by C. Reid, Mem. Geol. Survey, p. 3. (1882).

Zone of Ostrea lunata.

This zone (see p. 12) is only exposed in the bluffs and on the foreshore near Trimingham and Mundesley. It rises above the beach at two places, but one of these prominences has now been almost entirely worn away. The following account of the most northerly mass is from notes taken by myself in 1875, and published in 1880*:—

"The mass of chalk is about 35 yards long, and about 30 feet high, ending on each side with a nearly perpendicular face, ... and it is clear that much chalk has been carried away from both ends; (see Fig. 63), the front face stands out 8 or 9 yards from the base of this talus (from the foundering cliffs).

"The chalk contains bands of flints at distances of from 2 to 3 feet apart. Some of these are hard, black, and compact, but the majority are only half silicified, being hollow or partly filled with a grey, chalky matter, which is gritty to the touch, and is full of sponge spicules and minute organisms. The flints are, moreover, surrounded with similar greyish chalk, which sometimes forms a band connecting two or more together. This greyish chalk also occurs in places without enclosing any flinty matter, and gives a mottled appearance to the mass. Between the layers of flint nodules the rock is full of a small curved species of oyster (now identified as *Ostrea lunata*). *Belemnitella mucronata* is also common, and there are many other fossils, but the best specimens are adherent to the flints.

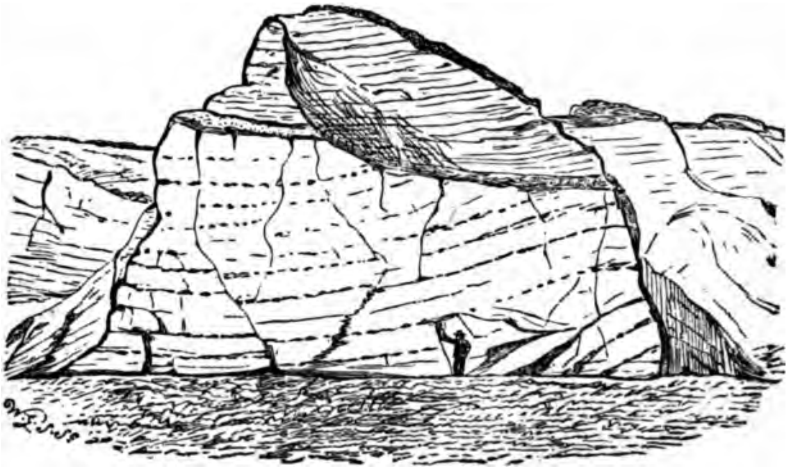

FIG. 63.—Sketch of Northern Bluff, Trimingham, in 1875.
From Ann. Mag. Nat. Hist., Ser. 5, Vol. VI., p. 306.

"If the measurements above given be compared with those of Sir Ch. Lyell, and the mass in its present state be compared with the figure in the early editions of the "Principles of Geology" (reproduced in Fig. 64) it will be seen that it has now only one-third of the length it possessed in 1839 (viz., 106 yards). Originally the front face seems to have exhibited a complete synclinal curve, with more than half of the corresponding anticlinal at the southern end; but now only the centre of the synclinal is left, the beds rising very slightly to the southern, and more decidedly towards the northern end."

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* The Chalk Bluffs of Trimmingham, Ann. Mag. Nat. Hist. Ser. 5, Vol. vi. p. 305.

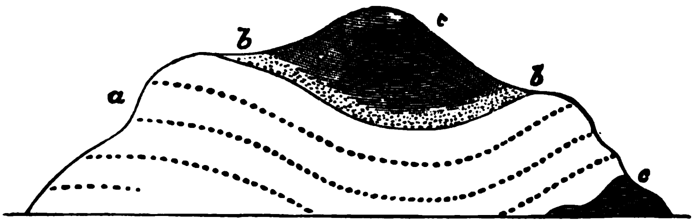

FIG. 64.—The Northern Bluff, Trimingham, 1839 (after Lyell).

a. Chalk.
b. Sand.
c. Boulder Clay.

With regard to the dip of the beds, as viewed from the sides, some difference of opinion has existed. It is seldom, indeed, that a clear section is exhibited by the side face, for the chalk breaks away along joint-planes which are often discoloured. Mr. Clement Reid, however, had opportunities of visiting the spot after winter storms had cleared the section, and he discovered that the beds are bent into a sharp curve or loop, and are so flexed as to be horizontal in one place and nearly vertical in another. The diagram (Fig. 65) is an enlargement of part of the section drawn by Mr. Reid.[*] The continuous line in the chalk indicates the position of a bed of gritty or sandy chalk, observed by Mr. Reid, about 12 inches thick. An analysis of this bed will be found on p. 359.

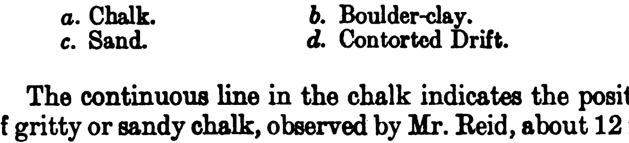

FIG. 65.—Northern Bluff, side view in 1878, (after C. Reid).

a. Chalk. *b*. Boulder-clay.
c. Sand. *d*. Contorted Drift.

Still more recently the Trimingham chalk has been again explored by Mr. Reid and by Mr. R. M. Brydone, both of whom have made large collections of fossils, and have kindly placed the following information at my disposal.*

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[*] See Geol Mag., Dec. 2, Vol. vii. p. 55 (1880).

Mr. Reid informs me that the chalk exposed is divisible into two portions, which may be regarded as sub-zones, and are separated by the sandy bed seen in the northern bluff. In the lower bed the large *Ostrea vesicularis* is common, but does not range above the sandy layer; while *Ostrea lunata* and *Thecidium vermiculare* are confined to the upper beds in which they are abundant. For figures of these, see pp. 23 and 25.

Mr. Brydone confirms the above remarks, and is inclined to think that four different beds are distinguishable in this chalk. He also measured the southern bluff, and found that it extends along the shore for about 110 yards, but the northern part is low and the southern part is not more than 30 feet in height. In the southern part the upper beds are clean and white, the lower beds are mottled by small irregular patches of greyish chalk. The dips shown by the layers of flints indicate a low anticlinal arch, the strike of which seems to be intersected by the seaward face. The lowest bed seen in the centre of the arch is a hard rough yellowish chalk, in which occurs a curiously shaped variety of *Echinocorys scutatus*, with a very thick test. Above this are about 9 feet of mottled chalk without *Ostrea lunata*, and then about 20 feet in which *O. lunata* is common.

The northern part of this bluff consists of soft marly chalk which differs from that of the southern part; it does not contain *Ostrea lunata*, though it has yielded most of the other fossils of the zone. The flints too are different, and Mr. Brydone thinks that it is separated from the southern part by a fault.

Mr. Brydone also discovered another exposure of chalk on the foreshore, near Mundesley, and over half a mile south of the two bluffs. This is probably rarely clear of sand, but was exposed in August, 1898, a block of chalk 25 feet long, six feet wide, and 2 feet high standing out of the sand. The beds appeared to dip at about 5° in a southerly direction, and in character and in fossils resembled those of the northern bluff.

In the same year (1898) a well was sunk in Mundesley, which passed through Glacial and Pliocene Beds into the chalk of the *O. lunata* zone. Mr. C. Reid informs me that the well passed through the following:—

	Feet.
Pleistocene and Pliocene Beds - - - - - - - - -	89
Chalk with *Ostrea lunata* and a layer crowded with that shell at 119 feet - - - - - - - - - - -	61
Chalk with flints—no fossils obtained - - - - - -	50
	200

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* Mr. Brydone has published his notes under the title of "The Stratigraphy and Fauna of the Trimmingham chalk" (Dulau & Co., 1900).

He believes from the character of the chalk and flints below 150 feet that all the chalk traversed (111 feet) belongs to the zone of *O. lunata.*

It will be seen from the following list of fossils, that a number of species occur in the zone of *Ostrea lunata*, which are not found in the zones below, and most of these are Rügen and Maestricht species. Bryozoa, too, are very abundant, both in the chalk and in the rough hollow flints, and many of the species, such as *Pachydera grandis*, *Sulcocava costulata*, *Homalostega erecta*, *H. vespertilio* and *Eschara galeata*, are characteristic of the Rügen chalk.

LIST OF FOSSILS FROM THE UPPER CHALK OF NORFOLK.

The following list has been compiled from several sources :—

The species recorded by Professor Ch. Barrois in his "Recherches sur le Terrain Crétacé de l'Angleterre" (1876).

The lists given in those memoirs of the Geological Survey which describe the western and central parts of Norfolk (Sheets 65, 66, 68, and 69 of the Survey Map).

A long list of the fossils found near Norwich was given by Mr. H. B. Woodward in his Memoir on the Geology of the Country Around Norwich (1881). The nomenclature of these lists has been revised, and some species of doubtful occurrence have been omitted. It is also possible that some which have been quoted from the Norwich Chalk were not really obtained at that place, but from other localities in East Norfolk.

The species recorded from the Norwich Chalk in the monographs on the *Cretaceous Echinodermata, Actinozoa,* and *Brachiopoda,* published by the Palæontographical Society.

The fossils from the Norwich Chalk in the Woodwardian Museum, Cambridge, a list of which has been communicated by Mr. H. Woods.

For the numerous entries in column five (Trimingham Chalk) I am mainly indebted to Mr. R. M. Brydone, who collected largely from this chalk in 1899, and published a list in 1900. In the determination of the species he received great assistance from Professor Deecke, of Greifswald, to whom most of the fossils were sent for comparison with those found in the Chalk of Rügen. Mr. Brydone has communicated a few corrections of, and additions to, his published list.

	Zones of H. planus and M. cortest.	Z. of M. coranguinum.	Zones of Marsupites and Act. quadratus.	Zone of Belem. mucronata.	Z. of Ostrea lunata.
For Fish, *see* General List.					
Cephalopoda.					
Ammonites [Haploceras] catinus, *Mant.*	–	–	–	4	–
„ [„] icenicus, *Sharpe*	–	–	–	4	–
„ [Lytoceras] Jukesi, *Sharpe*	–	–	–	4	–
„ [Pachydiscus] peramplus, *Mant.*	1	–	–	–	–
„ [„] Portlocki, *Sharpe*	–	–	–	4	–
„ [Phylloc.] Pergensi, *de Gross.*	–	–	–	4	–
„ [Pachyd.] Oldhami, *Sharpe*	–	–	–	4	–
„ sp.	–	–	–	–	5
Baculites Faujasi, *Sow.*	–	–	–	4	5
Hamites sp.	–	–	–	4	–
Crioceras ellipticus,* *Mant.*	–	–	–	4	–
Heteroceras, cf. polyplocus, *Roem.*	–	–	–	4	–
Actinocamax quadratus, *Defr.*	–	–	3	–	–
„ granulatus, *Blainv.*	–	2	3	–	–
Aptychus peramplus ? *Sharpe*	–	–	–	–	5
Belemnitella, lanceolata, *Schloth.*	–	–	3	4	5
„ mucronata, *Schloth.*	–	–	3	4	5
Belemnites, cf. strehlensis, *Fritsch*	1	–	–	–	–
Nautilus Bayfieldi,† *F. C. and*	–	–	–	4	5
Nautilus sp.	–	–	–	–	5
Gasteropoda.					
Avellana cassis, *d'Orb.*	–	–	–	4	–
Cerithium sp.	–	–	–	–	5
Dentalium sp.	–	–	–	4	5
Dolium sp.	–	–	–	4	–
Emarginula unicostata, *Seeley*	–	–	–	4	–
Nerinæa unicarinata, *Woodw.*	–	–	–	4	–
Pleurotomaria perspectiva, *Mant.*	–	2	–	4	–
Trochus Basteroti, *Brongn.*	–	–	–	4	–
„ (Cirrus) striatus, *Woodw.*	–	2	–	–	–
Turritella sp.	–	–	–	4	–
Turbo retifer, *Holz.*	–	–	–	–	5
Lamellibranchiata.					
Anomia subtruncata ? *d'Orb.*	–	–	–	–	5
„ sp.	–	–	–	4	–
Arca Geinitzi, *Reuss*	–	–	–	4	5
Avicula nitida, *Rose* (M.S.)	–	–	3	–	–
„ subnodosa, *Hag.*	–	–	–	–	5
Chama inæquirostrata, *S. Woodw.*	–	–	–	4	5
Cucullæa sp.	–	–	–	–	5

*** This species has been reported, but we cannot confirm its occurrence.—E.T.N.**

† The forms named *Deslongchampsianus*, *elegans*, and *radiatus* in previous lists are not those species, but belong to *N. Bayfieldi*.—E.T.N.

—	Zones of H. planus and M. cortest.	Z. of M. coranguinum.	Zones of Marsupites and Act. quadratus.	Zone of Belem. mucronata.	Z. of Ostrea lunata.
Homalostega erecta, *Hag.*	–	–	–	–	5
„ nonna, *Hag.*	–	–	–	–	5
„ pavonia, *Hag.*	–	–	–	4	5
„ vespertilio, *Hag.*	–	–	–	4	5
Lunulites cretaceus, *Defr.*	–	–	–	4	5
Meliceritites angulosa, *d'Orb.*	–	–	–	–	5
Membranipora dispersa, *Hag.*	–	–	–	–	5
„ velamen, *Goldf.*	–	–	–	–	5
Onychosella camerata, *Hag.*	–	–	–	–	5
„ koninckiana, *Hag.*	–	–	–	–	5
„ Lamarcki, *Hag.*	–	–	–	–	5
„ parisiensis, *d'Orb.*	–	–	–	–	5
Pachydera grandis, *Marss.*	–	–	–	–	5
Proboscina ramosa, *Edw.*	–	–	–	–	5
Porina filograna, *Goldf.*	–	–	–	–	5
Retecavea cretacea, *Edw.*	–	–	–	–	5
Reticulipora contingens, *Lonsd.*	–	–	–	4	–
Semiescharipora galeata, *Beiss*	–	–	–	–	5
Semimulticavea meudonensis, *d'Orb.*	–	–	–	–	5
Sparsicavea reticulata, *Marss.*	–	–	–	–	5
Spiropora verticillata, *Goldf.*	–	–	–	–	5
Stomatopora gracilis, *Edw.*	–	–	–	4	–
„ granulata, *Edw.*	–	–	–	–	5
Sulcocava costulata, *Marss.*	–	–	–	–	5
Systenostoma asperulum, *Marss.*	–	–	–	–	5
Vincularia abscondita, *Marss.*	–	–	–	–	5
„ exsculpta, *Marss.*	–	–	–	–	5
„ strumulosa, *Marss.*	–	–	–	–	5
Crustacea.					
Enoploclytia sussexensis, *Mant.*		–	–	4	–
Loricula pulchella, *Sow.*	–		–	4	–
Pollicipes Angelini, *Darw.*	–	–	–	4	–
„ cancellatus, *Marss.*	–	–	–	–	5
„ fallax, *Darw.*	–	–	–	4	5
„ striatus, *Darw.*	–	–	–	4	–
Pyrgoma cretacea, *H. Woodw.*	–	–	–	4	–
Scalpellum fossula, *Darw.*	–	–	–	4	5
„ maximum, *Sow.*	–	–	3 ?	4	–
Verruca prisca. *Bosq.*	–	–	–	4	–
Ostracoda (see General List).					
Annelida.					
Serpula ampullacea, *Sow.*	–	2	–	4	5
„ carinata, *S. Woodw.*	–	–	–	4	–
„ canteriata, *Hag.*	–	–	–	4	5
„ contracta, *S. Woodw.*	–	–	–	4	–
„ fluctuata, *S. Woodw.*	–	2	–	4	5
„ granulata, *Sow.*	–	2	–	4	5
„ ilium, *Sow.*	–	–	–	–	5
„ lituitis, *Defr.*	–	–	–	4	–

——	Zones of H. planus and M. cortest.	Z. of M. Coranguinum.	Zones of Marsupites and Act. quadratus.	Zone of Belem. mucronata.	Z. of Ostrea lunata.
Serpula lumbricus, *Defr.*	–	–	–	4	5
„ macropus, *Sow.*	–	–	–	4	5
„ obtusa, *Sow.*	–	–	–	4	–
„ plana, *S. Woodw.*	–	–	–	4	–
„ plexus, *Sow.* (=gordialis)	–	2	3	4	5
„ pusilla, *Sow.*	–	–	–	4	–
„ spirulæa, *Sow.*	–	2	–	4	–
„ striata, *Defr.*	–	–	–	4	–
„ trochiformis, *Hag.*	–	–	–	–	5
„ vortex, *S. Woodw.*	–	–	–	4	–
Terebella lewesiensis, *Davies*	–	–	–	4	–
Echinodermata.					
Bourgueticrinus ellipticus, *Miller*	–	2	3	4	5
Cardiaster grandis, *Benett*	–	–	–	4	–
„ ananchytis, *Leske*	–	2	–	4	5
Cidaris clavigera, *König*	–	2	–	–	–
„ hirudo, *Sorig.*	–	2	3	–	–
„ perornata, *Forbes*	–	2	–	–	–
„ sceptrifera, *Mant.*	–	2	3	4	–
„ serrata, *Desor*	–	–	–	–	5
„ vesiculosa ? *Goldf.*	–	–	–	–	5
Cyphosoma corollare, *Klein*	–	2	–	4	–
„ elongatum, *Cott.*	–	–	–	–	5
Cyphosoma granulosum, *Goldf.*	–	–	–	4	–
„ Kœnigi, *Mant.*	–	–	–	4	–
„ magnificum, *Ag.*	–	–	–	4	–
„ radiatum, *Sorig.*	1 ?	–	–	–	5
„ Wetherelli, *Forbes*	–	–	–	–	5
Echinocorys scutatus, *Leske*	1	2	3	4	5
Epiaster gibbus, *Lam.*	–	2	–	4	5
Galerites abbreviatus, *Desor* (=Rœmeri)	–	–	–	4	5
„ albogalerus, *Leske*	–	2	–	–	–
„ sp.	–	–	–	–	5
Holaster planus, *Mant.*	1	–	–	–	–
„ placenta, *Ag.*	–	2	–	4	–
Infulaster excentricus, *Rose*	–	2	–	4	–
„ rostratus, *Forbes*	–	2	–	4	–
Marsupites testudinarius, *Schloth.*	–	–	3	–	–
Metopaster Mantelli, *Forbes*	–	2	–	4	–
„ Parkinsoni, *Forbes*	–	–	–	4	–
Micraster coranguinum, *Leske*	–	2	3	4	5
„ cortestudinarium, *Goldf.*	1	–	–	–	–
„ præcursor, *Rowe*	1 ?	2	–	–	–
Offaster pillula, *Lam.*	–	–	3	4	–
Ophiura subcylindrica ? *Hag.*	–	–	–	–	5
Oreaster pistilliferus, *Forbes*	–	–	3	–	–
Pentacrinus Agassizi, *Hag.*	–	–	–	–	5
„ Bronni, *Hag.*	–	–	–	–	5

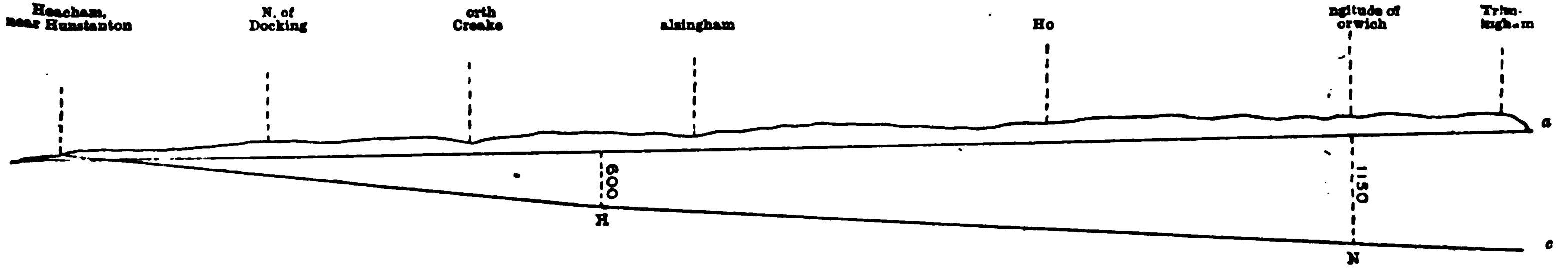

FIG. 60.—Section across the North of Norfolk from Heacham to Trimingham, to show the easterly dip of the Chalk, the line *c c* being its base and the line *a a* the approximate level of the sea.

Horizontal scale, 5 miles to 1 inch. Vertical scale, about 2,000 feet to an inch.

H represents the longitude of the Holkham boring, and N. that of Norwich.

all things into consideration we may venture on the following approximate thicknesses :—

	Feet.
Zone of Ostrea lunata	110
Zone of Belemnitella mucronata	250
Zones of Act. quadratus and Marsupites	400
Zones of M. coranguinum and M. cortestudinarium	340
Zone of Holaster planus	40
Middle and Lower Chalk	150*
	1,290

We have here included the whole of the zone of *Holaster planus* in the Upper Chalk, thus making its thickness 1,140 feet, but as stated in Volume II. p. 473 it is possible that some of the *H. planus* chalk really belongs to the Middle division, and there is at present no definite base line to the Upper Chalk of Norfolk.

STRATIGRAPHICAL DETAILS.

Zone of Holaster planus.

Only one section of this zone has been seen in the southern part of Norfolk; this is in the cutting on the railway which commences about 2 miles west of Swaffham Station; the locality was visited by Messrs. W. Hill and W. Whitaker in 1886,† and subsequently by the former alone in 1897; the following account of it is from Mr. Hill's later notes:—

At the western end of the cutting white chalk with greyish-black flints and containing *Holaster planus* is exposed for some 50 yards, dipping gently to the eastward. Near the eastern bridge a layer of large grey-black flints comes in, and about 2½ feet above this there is a bed of hard semi-crystalline creamy-white chalk, about 10 inches thick, lumpy or nodular at the top, and overlain by 4 inches of very marly, buff-coloured chalk. The hard bed contains a fair number of fossils, and the following were found by Messrs. Hill and Whitaker:—

Lamna (tooth).
Inoceramus (fragments).
Rhynchonella plicatilis (large).
„ reedensis.
Terebratula carnea.
Terebratula semiglobosa.
Holaster planus.
Micraster sp.
Cidaris (spines).
Cyphosoma radiatum.

Thus both in its lithological characters and in its fossils this bed resembles the Chalk Rock, but it does not contain glauconite nor any green-coated nodules.

The marly chalk is succeeded by white chalk with flints, and in this *Echinocorys scutatus* occurs, but was not found below.

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* The 102 feet of chalk without flints below Norwich is less than would be expected from the thickness of such chalk at the outcrop near Marham, where there must be at least 130 feet, but it is quite possible that the Lower and Middle Chalk become thinner toward the west.

† See Geology of South-Western Norfolk, etc., Mem. Geol. Survey, p. 39, (1893).

In the northern part of Norfolk the *Terebratulina* zone passes up into chalk which is still rather hard and contains layers of dark grey flints with occasional seams of flint which are often continuous for many yards. This chalk contains *Holaster planus*, and has been recognised at several localities within the area of Sheet 69. One of the best sections is in a quarry three-quarters of a mile N.N.W. of Great Bircham Church, and of this the following account is given by Mr. W. Hill :— *

		Ft.	*in.*
Soil and broken chalk - - - - - - - - -		3	0
Layer of large separate flat lenticular flints - - - -		0	·6
Chalk (much broken) with *Holaster planus* - - -		6	6
Layer of large grey-black flints - - - - - - -		0	6
Broken chalk with a few small scattered flints - - -		3	0
Layer of large massive flints - - - - - - -		0	9
Chalk- - - - - - - - - -	seen for	1	6
		15	9

Dr. Barrois had previously recognised these beds and their characteristic fossil in a quarry to the west of Bircham Newton, describing them as "hard white chalk with nodules of grey flint and grey tabular layers from 2 to 2½ inches thick and less than 3 feet apart. Between these flints there are large isolated flints similar to those which are so frequent in the Norwich chalk, and which are known by the name of Paramoudras."†

From this pit he obtained *Am.* [*Pachydiscus*] *peramplus*, *Echinocorys gibbus* and *Holaster planus*, and from a pit near Docking he got the two latter species with a Belemnite of which he says, "The presence of a Belemnite at this horizon is interesting; it is a fragment the precise determination of which is unfortunately impossible, but it is comparable with *Bel. strehlensis*, Fritsch."

? Zone of Micraster cortestudinarium.

Neither Professor Barrois nor Mr. Hill succeeded in positively recognising this zone in Norfolk, the reason being that, with the exception of *Echinocorys scutatus*, fossils are so rare in the chalk which may represent it that only one specimen of *Micraster cortestudinarium* has yet been found. But as stated in the memoir on the borders of the Wash (p. 70), if we eliminate those places where *Holaster planus* has been found, and those where *Micraster coranguinum* occurs, there is left a tract of country in which a few quarries exist, and the chalk seen in these may be referred provisionally to the zone of *Micraster cortestudinarium*.

The *Micraster* which has been identified by Dr. Rowe as *M. cortestudinarium* was obtained by Mr. Hill from a quarry near Swaffham, about half a mile west of the station, and on the south side of the line; the pit was from 25 to 30 feet deep in soft white chalk containing some scattered flints, and one bed 3 feet thick with many flints scattered through it; the flints are thin-skinned and black inside. Besides the *Micraster*, he found *Echinocorys scutatus*, and was told that *Belemnites* sometimes occurred.

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* Geology of the Borders of the Wash. Mem. Geol. Survey, p. 68 (1899).

† Recherches sur le Terr. Crét. Supérieur, p. 161.

This band of chalk runs from the neighbourhood of Castle Acre and Massingham Heath by Rudham, Tatterset, Bagthorpe, Barmer, and Syderstone, and thence northward by Stanhoe to Burnham Westgate. In the country between Castle Acre and Brandon no exploration of the Chalk has yet been made.

Two exposures of this chalk may be mentioned. One is about a mile north-east of Rudham railway station, and is described by Mr. Hill, who saw it in 1897, as about 30 feet deep in chalk with several layers of greyish-black flints, some rather large. He found a fragment of a Belemnite and a small *Rhynchonella Cuvieri*.

The other quarry, half a mile north-east of Houghton Church, was also visited by Mr. Hill, who writes—"It is in rather softer white chalk than is usual, and the flints are blacker and smaller in size. About 25 feet of chalk are shown, but the only fossils seen were a fragment of a *Cidaris* spine and a crushed *Echinocorys scutatus*.

Zone of Micraster coranguinum.

The chalk of the Brandon district has been described in the preceding chapter, and the chalk at and near Thetford must belong to the same zone, but the only references to it that I can find are (1) by C. B. Rose* in 1862, who remarks that "at Thetford cylindrical forms of flint from 18 to 24 inches in length are numerously distributed through the chalk," and that thin seams of flint are also seen; (2) by Mr. F. J. Bennett, in 1884, who mentions a pit about two miles north-east of Thetford, showing about 12 feet of soft rubbly chalk from which Mr. Rhodes obtained *Cidaris perornata*, an *Inoceramus*, and a sponge. (3) Mr. Rhodes also visited a pit half a mile north of the Mound, Thetford, (in sheet 51) and describes the chalk as soft, greyish and bedded; he obtained fish-teeth, and fossils identified as *Trochus cirrhus*, *Micraster præcursor*, *Bourgueticrinus*, and spines of *Cidaris*.

The chalk of this zone spreads northward by Mundford Stanford, Hilborough, Cressingham, and Watton, but the only published information refers to the chalk of Saham Tony and of Ashill, both near Watton.

Mr. Bennett has recorded the existence of two quarries, respectively, one and 1½ miles west of Saham Tony, both in soft chalk with layers of nodular flints.† From the first he obtained

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* Proc. Geol. Assoc., Vol. i. p. 231.

† Geology of the Country around Attleborough, etc. p. 3, (1884).

Micraster coranguinum and *Inoceramus*; from the second Mr. Rhodes collected *Inoceramus involutus, In. Lamarcki, Pecten cretosus*, and a *Spondylus*.

A little further north, and less than a mile west of Ashill, Mr. J. H. Blake found a large pit showing 30 feet of bedded chalk with layers of flint nodules. A few fossils were found here by Mr. Rhodes, viz., *Coscinopora quincuncialis, Parasmilia centralis*, a *Cidaris* spine, and *Inoceramus* (*cf. Brongniarti*).*

Swaffham has long been known as a locality for Chalk fossils, and lists were published by S. Woodward and C. B. Rose, but no careful collecting has been done there in recent years.

R. C. Taylor has remarked† that the disposition of the flints in the Swaffham chalk is peculiar, " two layers forming a pair being set at a distance of a foot apart and each pair at the distance of several feet from the next pair." Mr. Rose also remarked on the great size of the tabular flints, " many of them 8 or more feet in length and from 9 to 12 inches in thickness."‡ As these observations do not apply to the chalk in the quarry seen by Mr. Hill west of Swaffham Station, they must refer to that exposed in some of the old pits, of which there are many to the south and west of Swaffham. There are also old quarries near Castle Acre, four miles to the north, and at the Lexhams.

Litcham, about seven miles north-east of Swaffham, is another place where chalk has been quarried, and from which C. B. Rose obtained fossils. A quarry was still worked here in 1883 to the north-east of the church, and showed about 25 feet of chalk with 5 or 6 layers of black flint nodules and a few large irregular-shaped flints.§ There is another quarry about half a mile S.S.W. of Litcham, in which a few fossils were found by Mr. Rhodes.

To the north of Litcham, Lexham, and Rougham the Chalk is deeply covered by Boulder Clay, and little of it is again seen till we come to the valley of the Creake River. Here at South Creake there is a pit over 20 feet deep in rather hard chalk with layers of flints which are dark greyish-black inside. This pit has been visited by Prof. Barrois and by Mr. W. Hill, who both refer it to the zone of *Micraster coranguinum*. Mr. Rhodes has also collected from it and the neighbouring pits, and the fossils obtained are included in the list on p. 265.

The pits at Burnham Overy, north of the church, and east of Burnham Thorpe, are in the same beds, but fossils are less common.

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* Geology of the Country around East Dereham p. 11 (1888).

† Trans. Geol. Soc., Ser. 2, Vol. i. p. 378 (1824).

‡ Phil. Mag., Ser. 2, Vol. vii. p. 370 (1835).

§ See note by H. B. Woodward in the Geology of the Country around East Dereham, Mem. Geol. Survey p. 10 (1888).

2. Zones of Marsupites and Actinocamax quadratus.

These zones cannot be separated in Norfolk without more careful exploration than has hitherto been bestowed upon them, but Belemnites identified as *Actinocamax granulatus* and *Act. quadratus* occur throughout a considerable thickness of chalk. This chalk enters Norfolk between Brettenham and Diss, and runs northward in a broad band to the west of Wymondham, Reepham, and Holt (see Map, Fig. 59.)

Mr. Bennett* notes that a large pit north-west of Bridgeham shows 20 feet of soft thin-bedded chalk with a few flints, and that Mr. Rhodes obtained a few fossils from it, including a Belemnite (*Act. verus ?*). In another pit, one mile W.S.W. of Banham, he saw "15 feet of soft rubbly chalk with flints," and from this Mr. Rhodes obtained *Actinocamax granulatus* and other fossils.

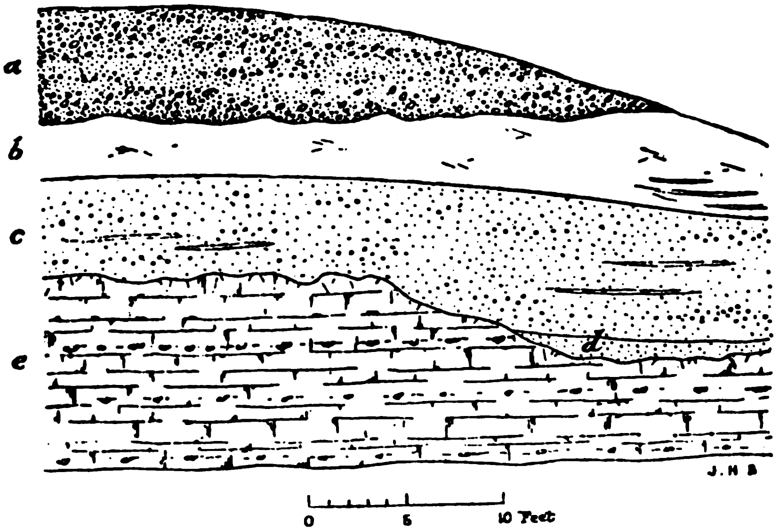

Fig. 61.—Section in a Quarry south-west of Ringland Church.

Glacial eds. { a. Gravel and sand.
b. Brown stony loam.
Pebbly Series. { c. Ash-coloured pebbly sand.
d. Orange-coloured sand.
Chalk. = e. Soft white chalk with some flints.

To the northward, within the area comprised by sheet 66 N.W., there are many exposures of chalk containing *Actinocamax* which are either *A. granulatus* or *A. quadratus*, and the pits have been described by the late Mr. J. H. Blake, in a memoir on the country round East Dereham (1888). From this memoir the following general account has been compiled :—

Near Ringland there are five or six pits which expose chalk

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*Geology of the Country around Attleborough, Mem. Geol. Survey, p. 4 (1884).

In another a quarter-of-a-mile S.W. of North Ormsby he found:—

Inoceramus Cuvieri
Ostrea vesicularis
„ sp. (small)
Magas pumilus
Rhynchonella Cuvieri
Micraster Leskei

A pit three-quarters of a mile N.N.W. of N. Ormsby is over 40 feet deep and shows the whole series of beds above mentioned; from this Mr. Burnet obtained *Rhynchonella Cuvieri, Terebratula carnea Holaster* (either *planus* or *placenta*), and *Echinocorys scutatus.*

Finally, in a quarry about half-a-mile south of Wyham he found that *Cidaris*-spines were fairly plentiful associated with *Rhynchonella Cuvieri.* The spine sent to me for identification appeared to be one of *C. sceptrifera.*

At and near Cadeby there are quarries showing a different set of beds which are probably in a higher part of the series, and possibly in the zone of *M. cortestudinarium.* In one of these I found a broken echinoderm, which seemed to be *Echinocorys scutatus* and in another the following succession is shown:—

	Ft.	*in.*
Broken chalk - - - - - - - - - - -	2	0
Large flat lenticular flints, nearly continuous - up to	0	6
Brittle white chalk with a thin layer of grey marl two feet from the base - - - - - - - -	6	0
Course of intermixed chalk and brown flint - - -	0	6
Beds of brittle white chalk with a course of large grey flint nodules - - - - - - - - -	14	0
	23	0

Another pit north-west of Lambcroft is 26 feet deep, and shows six layers of the intermixed flint and chalk with clearly marked upper and lower surfaces, the chalk in these layers being hard, while that in the other beds is soft and brittle. In this quarry Mr. Burnet has found *Kingena lima, Rhynch. Cuvieri* and a spine of *Cidaris perornata.*

Still further north by Hawerby, West and East Ravendale, Wold Newton, Hatcliffe, Irby and Riby, there are many quarries which show portions of the same series of beds as have just been described. One at West Ravendale showed exactly the same set of beds as those near North Ormsby. Quite recently (1903) Mr. Burnet has collected the following fossils from this district—*Inoceramus Cuvieri ? Ostrea vesicularis, Spondylus latus, Magas pumilus, Rhynchonella Cuvieri, Terebratula carnea and Holaster planus ?*

Mr. Hill made another reconnaissance in North Lincolnshire in 1899, and succeeded in finding chalk with *Holaster planus* in a quarry half a mile south-east of Kirmington, near Brocklesby. He describes the beds seen in this quarry as follows:—

	Ft.	*in.*
Soil and rubble - - - - - - - - - -	4	0
Hard white chalk weathering into thin irregular platy pieces - - - - - - - - - - - -	1	9
Continuous layer of solid grey flint - - - -	0	5

	Ft.	*in.*
Hard white chalk, as above with a layer of flat lenticular flints - - - - - - - - - - - - -	3	6
Continuous layer of solid grey flint - - - - - -	0	6
White chalk, rather soft and shaly at the top, *Hol. planus.*	1	0
Hard white chalk, breaking into thin flattish pieces -	3	6
Grey flint, nearly continuous, but separated in places into detached tabular flints - - - - - - - -	0	6
Hard white chalk with only a few scattered nodular flints	9	0
About	24	0

The quarry at Limber Parva is in similar chalk, but Mr. Hill could not find fossils of any kind. Mr. Reid was informed that at Mr. Frankish's house in Great Limber " a well was sunk to a depth of 168 feet entirely in chalk with layers of flint."* He also mentions several pits in which the curious layers of imperfect flint, or intermixed flint and chalk, are seen ; one of the best exposures of these beds being in a quarry one mile west of Ulceby, which is 30 feet deep. " At one spot near the bottom of this pit there is an enormous flint nodule, which bends the beds as though it were a boulder dropped from above " (*op. cit.*, p. 125). Other large upright flints have been noticed at Wold Newton and at Burnham. Between Burnham and Barrow there are many pits in chalk with tabular and continuous flints. In one east of Burnham Mr. Reid found fragments of a sulcated *Inoceramus* (*? digitatus*), and in one at Barrow Mr. Hill found an *Echinocorys scutatus*.

2. YORKSHIRE.

GENERAL DESCRIPTION.

The Upper Chalk of Yorkshire, and especially that of Flamborough Head, has been described in more or less detail by several observers, the more recent of such notices being those by Professor C. Barrois,† Rev. J. F. Blake,‡ and Mr. G. W. Lamplugh ;§ and to Professor Barrois belongs the credit of first indicating the lines on which the Yorkshire succession may be compared with that of the more southern counties. His account of the zonal succession in the cliffs west of Flamborough Head is still the most complete in existence, but Dr Rowe has recently made a more detailed examination and his results will doubtless add much to our knowledge.

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* The Geology of Parts of North Lincolnshire, etc., Mem. Geol. Surv., p. 125 (1890).

† Recherches sur le Terrain Crétacé supérieur, p, 196 et seq. (1876).

‡ On the Chalk of Yorkshire, Proc. Geol. Assoc., Vol. v. p. 232, (1878).

§ Notes on the White Chalk of Yorkshire, Proc. Yorksh. Geol. and Pol. Soc. Vol. xiii. p. 65 and p. 171 (1895 and 1896).

Mr. Blake made an attempt to follow these divisions through the inland parts of the country, and though he found himself unable to accept Professor Barrois' zonal classification, owing principally to the small number of fossils he could detect, yet he formulated a classification based on the characters of the flints in that portion of the series in which they occur. This classification is not without value, and a part of his table is given below :—

—	Lithology.	Palæontology.	Thickness.
1	Soft chalk without flints - -	Zone of Marsupites - - -	320
2	Chalk with imperfect flints -	Zone of Micrasters - - -	120
3	Chalk with tabular flints - -	barren zone - - - -	50
4	Slaty chalk with thin flints -	Zone of Inoc. mytiloides - -	200
5	Creamy chalk with nodular flints		

As already mentioned the "creamy chalk with nodular flints" belongs to the Middle Chalk, but the position of the "slaty chalk," No. 4, is less certain, for we have not been able to identify it in the Buckton cliffs, and the only other section of it which is clearly located by Mr. Blake (that at Swanland Mill) appears from the fossils to belong to the zone of *Hol. planus.*

His chalk with many tabular flints is undoubtedly the chalk which both Professor Barrois and ourselves refer to the zone of *Hol. planus,* and it is not so barren as Mr. Blake represents, though often so hard that fossils cannot be extracted in good condition. It is clearly the continuation of the similar chalk in Lincolnshire, and as in both counties it also contains *Echinocorys scutatus* we regard it as the equivalent of the hard nodular chalk of the south-east of England, and of the Chalk Rock found in the intermediate counties.

To the above succeeds chalk with Micrasters and *Inoceramus involutus,* evidently corresponding to the zones of *M. cortestudinarium* and *M. coranguinum* in the south. Lastly comes a great thickness of chalk without flints belonging to the zones of *Marsupites* and *Actinocamax quadratus* ; but the higher zone of *Belemnitella mucronata* does not seem to be exposed.

Mr. Lamplugh's papers are less concerned with palæontology, but they contain some useful measurements and some excellent photographic views of the cliffs. He set himself to estimate the thickness of the several portions of the Chalk, and arrived at results which show a much greater thickness than had previously been supposed. These are given by him as follows :—

	Feet.
Upper Chalk without flints - - - - - - -	650
Middle Chalk with flints - - - - - - - -	460
Lower Chalk without flints - - - - - - -	130
	1,240

Some thickness of the chalk with flints belongs to the Upper Chalk, and if we thus assign 200 feet the relative thicknesses of the three stages will come out as follows:—

	Feet.
Upper Chalk	+850
Middle Chalk	260
Lower Chalk	130

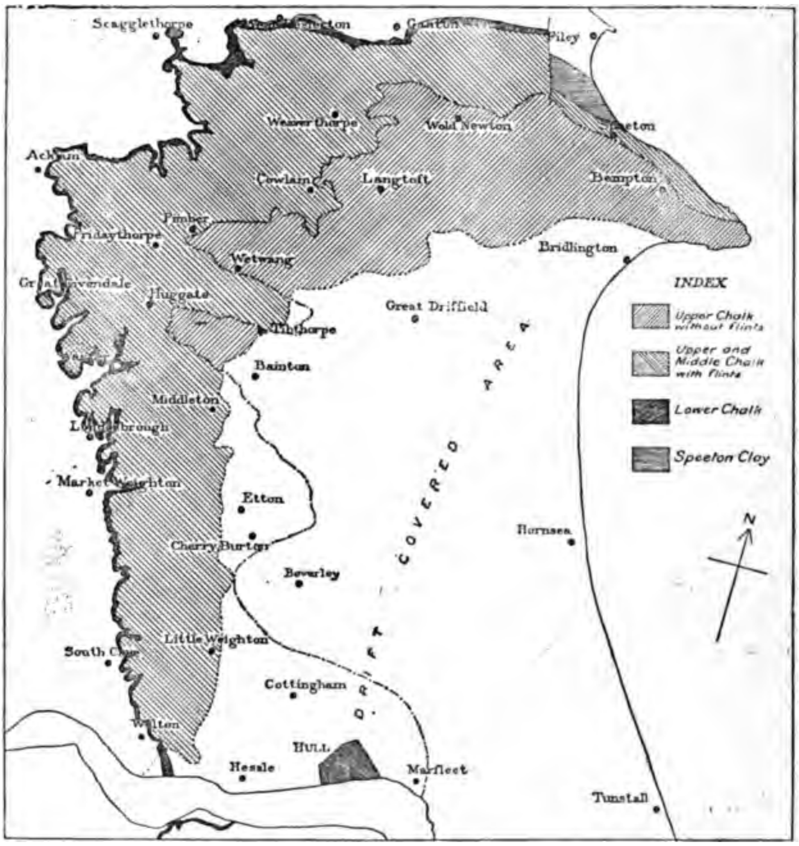

FIG. 66.—Sketch map of the Chalk-area in Yorkshire.

About twenty-five years ago Mr. R. Mortimer published some account of the distribution of flints in the Chalk of Yorkshire,* with a sketch map of the areas occupied by the flintless and the flint-bearing chalk respectively. One of the most interesting parts of this paper is the evidence of the eastern extension of the flint-bearing chalk below Hull, while throughout the rest of Holderness the Drift deposits rest on the flintless chalk.

Mr. Mortimer was inclined to think that the flintless chalk passed into that with flints, and that the two divisions were merely different lithological facies of one contemporaneous mass of chalk, but the zonal succession in the Yorkshire Chalk is now too well established to permit such a view to be maintained at the present day. The evidence which he presents can be interpreted much more naturally on the supposition that the strike of the beds curves round to the eastward in South Yorkshire just as it does toward Speeton and Flamborough. This view is represented on the accompanying map of the Yorkshire Chalk (Fig. 66).

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* See Proc. Geol. Assoc., Vol. v. p. 344 (1878).

This view finds some confirmation in the great thickness of chalk which is said to have been traversed by a boring at Hornsea,[*] the chalk being reached at 120 feet, and chalk without flints pierced for 858, the boring ending in "soft black warp or clay," which, as Mr. Lamplugh suggests, may be one of the marly seams in the Chalk. If this depth was really entirely through the flintless chalk the total thickness of the Yorkshire Chalk will be about 1,450 feet, for Hornsea must be very nearly in the centre of the basin.

STRATIGRAPHICAL DETAILS.

Zone of Holaster planus.

This zone appears to set in at and west of the village of Hessle, and as indications of it we have taken the lowest beds which contain the well-known echinoderms, *Holaster planus* and *Echinocorys scutatus.*

About half a mile west of Hessle Church, on the road to North Ferriby, is a quarry which was visited by Mr. Hill in 1899, and he found it to be about 25 feet deep, showing chalk with two conspicuous floors of flint and a well-marked layer of marl near the bottom. In the broken chalk at the top he found a fragment of *Echinocorys scutatus,* and what appeared to be a piece of a *Micraster.*

Mr. J. F. Blake has recorded a section in a quarry at Swanland Mill, which is about a mile north of Ferriby, which he gives as follows:—

	Feet.
Brittle chalk in thin beds, and numerous bands of thin flint	14+
White chalk with four thin flint bands, *Terebratula semiglobosa* - - - - - - - -	14
Continuous doggery flint, banded toward the outside, *Ananchytes ovatus* and *Inoceramus Cuvieri* -	1
Chalk becoming more flaggy and argillaceous below till it becomes almost a shale - - - - - - -	6
Chalk with flint bands from 6 to 8 inches thick every 2 feet	6
More than	40

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[*] C. Reid, Geology of Holderness Mem. Geol. Survey; p. 141 (1885). and G. W. Lamplugh, Proc. Yorksh Geol. and Pol. Soc., Vol. xiii. p. 71 (1895).

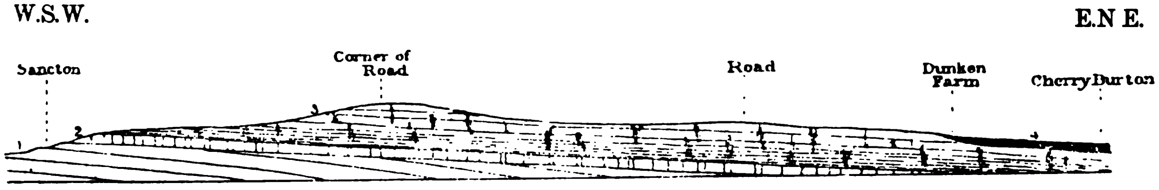

FIG. 67.– Section across the Chalk Wolds between Market Weighton and Beverley.

Horizontal Scale, 1 mile to an inch. Vertical Scale, 800 feet to an inch.

4. Glacial Deposits.
3. Upper and Middle Chalk.
2. Lower Chalk.
1. Jurassic Rocks.

Mr. Hill also discovered another section in this zone in a quarry west of Goodmanham Lodge, and easily accessible from the Kipling Cotes station on the railway from Weighton to Beverley; of this quarry he communicates the following account:—

	Ft.	*in.*
Smooth and firm white chalk - - - - - -	6	0
Layer of intermixed flint and chalk - - - - -	0	8
Firm white chalk, with *Holaster planus* - - -	1	6
Layer of flint and chalk, as above - - - - - -	0	6
Firm white chalk - - - - - - - - - -	2	0
Continuous floor of flint - - - - - - - - -	0	6
Firm white chalk with *H. planus* - - - - - -	3	3
Continuous floor of flint - - - - - - - - -	0	6
Firm white chalk with a marly layer about 9 inches from top - - - - - - - - - - - - - -	3	0
About	18	0

Mr. Hill says: "The chalk weathers into thin platy or flaggy pieces. *Holaster planus* is not rare, as I obtained four specimens besides portions of others, which seemed to be *planus*." Fig. 67 is a section across the outcrop of these beds.

Further north, in a cutting on the new railway, a mile west of Enthorpe Station, Mr. Hill found a good section, which seems to show a large part of the *Hol. planus* zone with some still higher beds, the succession being as follows:—

	Feet.
White chalk with layers of grey flint - - - - -	+ 60
A marked layer of continuous flint - - - - -	½
Firm white chalk with fewer grey flints in irregular layers. *Echinocorys scutatus* - - - - - - - - -	18
Firm white chalk with large grey flints in irregular layers. *Ech. scutatus* - - -	10
Firm white chalk with large flint doggers forming nearly continuous floors at distances of about 3½ feet. Several fossils found including *Hol. planus* and *Ech. scutatus* -	15
Well marked layer of marl - - - - - - -	
Broken chalk (a few feet) - - - - - - - -	
Over	103

The well-marked layer of marl above noted can be traced for 50 or 60 yards, till the dip carries it below the level of the rails.

We have no further positive information about the inland exposures of this zone, but we believe that it would not be difficult to trace it by Sherburn and Burdale and thence eastward toward the coast.

Passing now to the cliffs, north of Flamborough Head, we find the zone of *Hol. planus* coming into them at Thornwick and North Sea Landing. It was recognised here by Professor Barrois in 1876, and I paid a short visit to the locality in 1880 under the guidance of my colleague, Mr. Fox-Strangways. It is probable that in Thornwick Nab and Little Thornwick Bay we have the junction of the zones of *Terebratulina* and *Hol. planus ;* Professor Barrois says: " At Thornwick Nab the chalk is very poor in fossils, it is homogeneous and rather hard, and contains few flints. I obtained from it many *Inocerami* (*I. Brongniarti*)."

I examined the chalk of Little Thornwick Bay in 1880 and made the following note : The upper beds seen here contain large nodular grey flints, below these are thin-bedded strata which contain crushed Echinoderms, probably *Holaster planus,* but none sufficiently good for certain determination; these occur specially along one horizon below which I could find nothing but large *Inocerami.*

Mr. Hill visited Great Thornwick Bay in 1899 and communicates the following note: On the west side of the bay the lowest beds consist of hard white massive chalk which contains a layer of yellowish brown nodules, reminding me strongly of the nodular lumps which occur at the top of the Middle Chalk in the south-east of England and so often show iron-stained traces of Sponges. Above these beds is a layer of large grey flints forming a nearly continuous floor. On the eastern side of the bay the following section may be measured :—

	Ft.	*in.*
Very hard white chalk weathering into flattish angular fragments, with several layers of tabular flint - -	12	0
Hard chalk without flints - - - - - - -	5	6
Layer of very large flat lenticular masses of grey flint up to	0	9
Hard white chalk in massive beds - - - - - -	5	6
Layer of large separate grey flints (as above) - - -	0	9
Hard white chalk, well bedded, without flints - -	2	9
Layer of separate grey flints (as above) - - - - -	0	6
Firm white chalk in thick beds with scattered flints -	10	0
Hard white chalk, with a layer of flat lenticular flints down to the same layer of flints as is seen on the west side of the bay, here at the tide line - - - - - -	10	0
	47	9

The place where this section was taken is shown in Plate II (Vol. II), for which we are indebted to Mr. G. W. Lamplugh and the Council of the Yorkshire Geological and Polytechnic Society.

The only fossils found were a fragment of a *Micraster* and a cast of *Rhynchonella* in oxide of iron. At North Sea Landing the upper part of this section is repeated in a sort of gully washed out by a small stream, where Mr. Hill found a thin-shelled *Holaster* which is either *H. planus* or *H. placenta,* and a piece of *Echinocorys scutatus.*

In 1880 I had noted that the chalk with Holasters is overlain by a bed of hard compact semi-crystalline limestone (like that at

Hessle), and that the succession near the big arch on the west side of the North Sea inlet is as follows:—

	Ft.	*in.*
Hard chalk with layers of large grey tabular flints	? 70	0
Thin layer of banded flint, grey with yellow edges	0	1
Hard yellowish chalk	1	3
Layer of grey flint with yellow stains	0	6
Hard compact (? siliceous) limestone	3	0
Chalk with flints in thick beds	20	0

Professor Barrois obtained the following fossils from North Sea Landing:—

Inoceramus.
Terebratula semiglobosa
Terebratulina striata.
Rhynchonella Cuvieri.
Holaster planus.
Cidaris hirudo.
Echinocorys gibbus.
Bourgueticrinus.

Mr. Lamplugh says that in the south-west corner of the Landing inlet "there occurs a thin seam containing fragments of the stems or arms of a crinoid (probably *Bourgueticrinus*) in abundance." On his sketch-map he marks a dip of 6° to the south as shown in these and the adjoining cliffs.

It is impossible to follow the section eastward toward Brail Head, for the sea washes the foot of the cliffs even at low tide, and they form nearly vertical walls which are about 140 feet high.

Zone of Micrasters.

This includes the remainder of the chalk with flints in Yorkshire, but whether it can be divided into zones of *Micr. cortestudinarium* and *M. coranguinum* we have not at present sufficient evidence to decide.

The most southerly place in Yorkshire where, to our knowledge, Micrasters have been found is near Little Weighton, a village about 4½ miles south-west of Beverley. Mr. J. W. Stather, of Hull, has kindly allowed me to see a *Micraster* recently obtained from the cutting near Little Weighton tunnel, and I find the specimen to be a transition form between *M. Leskei* and *M. præcursor* (having a feebly marked subanal fasciole); hence I should suppose the beds from which it was obtained to be low down in the zone of *M. cortestudinarium*.

This zone was formerly exposed in a cutting on the Weighton and Beverley line west of Kipling Cotes station, but is now grassed over. In 1880, while the section was fresh, Mr. H. A. Allen obtained the following fossils from this cutting:—

Inoceramus.
Lima.
Ostrea vesicularis.
Terebratula semiglobosa.
Echinocorys scutatus.
Micraster præcursor.
Ventriculites.
Camerospongia ?

The same beds must be exposed in the more recent cutting west of Enthorpe on the Weighton and Driffield line, for Mr. Hill informs me that this shows over 100 feet of chalk above the beds in which he found *Holaster planus* (see p. 280), but that he could not find any perfect Micrasters in them.

Mr. J. F. Blake states (op. cit. p. 256) that the higher part of the flint-bearing chalk is well exposed on Huggate Wold and southward to Millington; "here is the home of the wonderful *Inoceramus involutus*, of which Mr. Mortimer has several perfect, in both valves [in the Museum at Driffield] . . . . I found this in more than one quarry so that it cannot be scarce . . . . Associated with it are *Terebratula carnea, Spondylus latus, Ananchytes ovatus, Ventriculites simplex, Brachiolites,* and *Scyphia pedunculata.*"

He also remarks that Mr. Mortimer has obtained many fossils from these beds near Fridaythorpe, Fimber, Towthorpe, and Sutton. Among these he mentions a large *Ammonites, Inoceramus digitatus, Micraster cortestudinarium* (from Burdale) and *Infulaster excentricus.*

Mr. Blake designates these beds as the "chalk with imperfect flints," because, like the layers described on p. 272, many of the larger masses consist partly of flint and partly of chalk. He describes them as follows, "their exterior is generally, but not always, well marked; but on breaking them open they are found to be by no means entirely composed of flint, but are rather an aggregate of angular masses of siliceous matter shading off rather rapidly into calcareous, and enveloped in a siliceous envelope."

In the quarry near Weaverthorpe Vicarage which is assigned to this zone by Mr. Blake the beds are vertical and are probably in close proximity to a line of fault. According to the same writer the Micraster zone is well exposed in the "Butts quarry" south of Hunmanby; he describes the chalk there as softer than in the lower beds, but flints as abundant. He mentions *Inoceramus Brongniarti, Echinocorys gibbus,* and *Micraster coranguinum* as occurring in this quarry, some of them bearing Polyzoa and valves of *Spondylus latus.*

On the northern coast of Flamborough Head the greater part of the Micraster Beds are inaccessible, as they form vertical cliffs, the base of which is nearly always washed by the sea, and can only be viewed from a boat.

The highest beds, however, are accessible in Selwick's Bay. This bay, as Mr. Lamplugh has pointed out, owes its existence to a line of fault which runs approximately from north-east to south-west, and has an upthrow on the south-east side of between 70 and 80 feet. The effect of this fault is to bring up the Chalk-with-flints, which on the northern side of the bay sinks to the level of the scar, but on the southern side beyond the fault occupies nearly the whole of the cliff. Mr. Lamplugh managed to measure the beds in the eastern part of this cliff, and th following is condensed from the particulars given by him; the section in descending order is:—

	Ft.	in.
First flints, a band of grey and yellowish nodules [in ascending order these are the highest or last flints] -	0	2
Hard flaggy chalk - - - - - - - - - -	8	0
Band of soft marl - - - - - - - - -	0	4
Hard flaggy chalk with a layer of marly chalk at base -	3	6
Compact flaggy and rather lumpy chalk with two layers of ramose and palmate flints - - - - - -	19	8
Line of occasional flints of larger size.		
Compact flaggy chalk with flints both scattered and in layers - - - - - - - - - - -	14	0
Compact bedded chalk with a band of grey flints in the middle - - - - - - - - - - -	11	0
Line of scattered flints and flint in joints		
Bedded chalk with many layers of thin palmate flints -	13	0
Compact chalk, to base of cliff - - - - -	6	0
	75	8

Zone of Marsupites.

Under this head we shall include the greater part of what has usually been called in Yorkshire "the Upper Chalk without flints." From the account published by Mr. Lamplugh, and from further information furnished by Mr. J. W. Stather, of Hull, it appears that this flintless chalk is capable of being divided into two parts or zones; the lower part may be termed the zone of *Marsupites*, from the abundance of that fossil in its upper portion; the upper part is characterised by *Cardiaster ananchytis* and some other fossils, while *Actinocamax granulatus* occurs in both parts.

Such a division was suggested, in 1876, by Professor Barrois, who referred to Schlüter's sub-division of the *Act. quadratus* chalk of the Münster district into two parts — namely, a lower zone of *Inoceramus lingua* and *Scaphites binodosus*; an upper zone of *Becksia Soekelandi* (a sponge)—and Professor Barrois then remarked that "these sub-divisions are quite recognisable in Yorkshire; the zone of *Becksia Soekelandi* is specially characterised by the abundance of sponges, and it is a fact that the beds of Danes Dyke, which are so rich in Sponges, also occur in the upper part of this zone of *Marsupites*, near Bridlington."*

In Yorkshire, however, neither *Inoceramus lingua* nor *Scaphites binodosus* are restricted to the lower zone, the Scaphite, indeed, having only yet been found in some quarries near Bridlington, which must be in the higher zone. The lower part is, therefore, more satisfactorily defined by the upper limit of the range of *Marsupites*. Remains of this Crinoid occur chiefly in certain beds near Danes Dyke, which have a thickness of 53 feet, and some have been found lower down, giving a thickness of more than 120 feet for this subzone; none have yet been obtained from the lower 273 feet of this flintless chalk, some or all of which must represent the subzone of *Uintacrinus*. *Actinocamax granulatus* and *Inoceramus lingua* range down to the very lowest beds, and it will be convenient for the present to class all this lower portion in the zone of *Marsupites*, which thus, according to Mr. Lamplugh's measurements, has a thickness of 402 feet.

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*Recherches sur le Terr. Crét. Supérieur, p. 109.

In the extreme south-eastern part of Yorkshire the chalk of the *Marsupites* zone is either absent or concealed by the glacial deposits, but it comes in a little to the south of Beverley, and is exposed in three large quarries at that place. For the following information about these I am indebted to Mr. J. W. Stather. The largest is that of the Victoria Whiting Works, which is about 100 feet deep; east of this is the Queensgate pit which is nearly as deep, and the third (Davis' pit) is about 60 feet. The whole of the chalk exposed is flintless, and a boring now being made (1899) at the Beverley Waterworks (close to the Victoria pit) reached the first flints at 176 feet from the surface. Plates of *Marsupites* are common in a band near the top, *Actinocamax granulatus* is common throughout, as is *Echinocorys scutatus*. *Cidaris sceptrifera*, and a few other fossils have been obtained.

The following particulars respecting the chalk exposed in Davis's pit are quoted from the "Transactions of the Hull Geological Society for 1895–6," but Mr. Stather having sent me the Belemnites for examination, I am able to state that they are all referable to *Actinocamax granulatus* :—

	Ft.	*in*
Chalk rubble	10 to 15	0
Solid chalk with *Marsupites* and *Rhynchonella*	5	0
Soft chalk	1	3
Very hard chalk used for road metal	8	9
Thin layer containing many *Act. granulatus*	0	6
Compact chalk	12	6
Thin earthy band		
Hard chalk with *Rhynchonella*	6	0
Chalk with *Echinocorys scutatus* and *Act. granulatus*	7	0
About	56	0

From Beverley the flintless chalk runs northward by Kilnwick and Bainton, and its boundary has been mapped by the Geological Survey round a synclinal, which runs out eastward toward Huggate (see Fig. 66), curving back by Tibthorpe and Kirkburn. West of Driffield it comes in again by Garton and Wetwang, and spreads northward over a large area, as well as eastward to Bempton, Flamborough, and Bridlington.

Mr. Mortimer* mentions a quarry a quarter of a mile north of Wold Newton, which exposes over 40 feet of flintless chalk, and Mr. Stather informs me that he has obtained plates of *Marsupites* from a small quarry near Bartingdale Farm, 3 miles south of Hunmanby and from one a little east of Flamborough Railway Station.

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* Proc. Geol. Assoc., Vol. v. p. 351 (1878).

Coming now to the coast section, we find the junction of the zone of *M. coranguinum* with that of *Marsupites* exposed in Selwick's Bay, on the north side of Flamborough Head. The fault in this bay has already been mentioned, and it was probably on the west side of the bay that Professor Barrois took the section given in his "Recherches" (p. 197). Of this the following is a translation:—

	Feet.
White chalk without flints - - - - - - - - -	33
Thin layer full of fragments of *Inocerami* - - - - -	0
Chalk without flints, in beds of from 4 to 15 inches thick with irregular, yellowish, indurated surfaces - - - -	16
Chalk with seams of grey marl and two layers of grey flints, one thin and tabular - - - - - - - - -	16
	65

Plate III (Vol. II), shows the basal part of the zone of *Marsupites* as exhibited in the cliffs on the northern side of Selwick's Bay at a point known as Kindle Scar. Like Plate II it is borrowed from Mr. Lamplugh's paper on the White Chalk of Yorkshire.

The junction can be seen again at High Stacks, the most eastern promontory of the headland where according to Mr. Lamplugh, a little over 100 feet of the Chalk without flints come in between High Stacks and South Sea Landing. The distance is about two miles, but the coastline here runs nearly at right angles to the dip. The chalk is of uniform character, being hard and flaggy, with many thin seams of marl, and from this part of the coast-section Mr. J. W. Stather has obtained numerous small fossils, including *Infulaster rostratus*, *Cidaris* (spines), *Parasmilia*, etc. One of the most productive bands occupies the base of the cliff from East Nook to Cattlemere Scar, a distance of about a mile and a half.*

Professor Barrois also collected from the same line of cliff and obtained fourteen species, the most notable being *Belemnites Merceyi* (= *granulatus*), *Inoceramus lingua*, *Terebratula sexradiata*, *Marsupites ornatus*, *Offaster corculum* (=*pillula*), and *Parasmilia monilis*. He remarks on the absence (or great rarity) of Micrasters, and observes that Schlüter has called attention to their absence in the zone of *Act. quadratus* in some parts of Germany.

Between South Sea Landing and Danes Dyke is a distance of about a mile, but as the dip becomes rather more pronounced and its direction is south-west, higher and higher beds are brought in, and Mr. Lamplugh measured a thickness of 214 feet between these two spots. Most of the beds which he enumerates are described as flaggy chalk with occasional thin seams of marl, but here and there he mentions the occurrence of more massive compact bands from 1½ to over 2 feet thick. Fossils are not abundant in this series of beds, but Mr. Lamplugh obtained *Act. granulatus* and some Echinoderms from the upper part, and Professor Barrois found *Actinocamax verus, Ostrea vesicularis,* and *Bourgueticrinus ellipticus.*

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* Lamplugh, Notes on the White Chalk of Yorkshire, Proc. Yorksh. Geol. and Pol. Soc., Vol. xiii. p. 84 (1895).

Mr. Lamplugh allows 30 feet for the valley interval where the chalk is not actually seen at Danes Dyke, and above this he found a thickness of 53 feet, in which plates of *Marsupites* occur. From his description most of this consists of soft white chalk which weathers into thin platy or flaggy pieces, but there are occasionally thicker beds of firmer chalk, and occasional seams of marl. *Marsupites* are most abundant in the upper 26 feet of this chalk. Professor Barrois obtained fourteen species of fossils from this band, including *Inoceramus lingua, Cyphosoma Kōnigi,* three species of *Cidaris, Marsupites testudinarius,* and *Caryophyllia cylindracea.*

Zone of Actinocamax quadratus.

Assuming that the highest bed in which Mr. Lamplugh found remains of *Marsupites* is the top of that zone, then the overlying beds which come in near the headland west of Danes Dyke must represent the lower part of the zone of *Act. quadratus* as developed in the South of England. It is true that *Act. quadratus* has not yet been found in Yorkshire, all the Belemnites found by Mr. Lamplugh and Mr. Stather being referable to *Act. granulatus,* but the typical *Act. quadratus* is a rarer fossil in England.

These upper beds of the coast section are characterised by the abundance of Sponges, and by the occurrence of *Cardiaster ananchytis,* but *Offaster pillula* seems to be rare, so that the fauna differs in some respects from that of the beds which are presumably their equivalents in the southern counties.

From Mr. Lamplugh's account we learn that the beds which contain *Marsupites* are succeeded by chalk which differs little in lithological aspect, consisting of alternating beds of flaggy and compact chalk with occasional seams of marl. It is in this portion of the section that the Calcispongia are so abundant, their occurrence constituting one of the most striking peculiarities in the palæontology of the Yorkshire Chalk. Many genera are present, including *Phymatella, Bolospongia,* and *Stichophyma,* and in higher beds *Verruculina, Seliscothon,* and *Scytalia. Actinocamax granulatus* is not rare. Mr. Stather has found *Cardiaster ananchytis,* and *Infulaster,* and Prof. Barrois records *Offaster pillula.* These beds have a thickness of about 120 feet.

The very highest beds under Sewerby Park consist of chalk which weathers into thin flaggy pieces, about 35 feet being exposed. Mr. Stather reports that *Cardiaster ananchytis* is not uncommon. *Ventriculites cribrosus* and other sponges also occur.

The exposures on White Hill north-west of Bridlington, and on Bessingby Hill to the south-west must be in higher beds than any seen along the coast, and for these Mr. Lamplugh allows an additional thickness of 100 feet.

A sharp-keeled Ammonite, obtained by Mr. Stather from the *Marsupites* zone at Beverley, was sent to Mr. G. C. Crick, of the British Museum, who states that it comes nearest to *Am. pseudo-gardeni* of Schlüter. Two *Scaphites*, obtained by Mr. Stather at White Hill, were recognised as probably *Sc. binodosus* by Mr. E. T. Newton.

Fossils of the Upper Chalk of Yorkshire.

The following list of fossils has been compiled from several sources; the authorities for the occurrence of the species are indicated by letters, and are as follows:—

B.—Species recorded by Professor Barrois in his "Recherches sur le Terrain Crétacé de l'Angleterre et de l'Irlande" (1876).

H.—Species described by Dr. Hinde in his Catalogue of the Fossil Sponges in the British Museum.

L.—Fossils in the collection of Mr. G. W. Lamplugh, identified at Jermyn Street.

M.—Fossils in the collection of Mr. Mortimer, of Driffield, recorded by Mr. J. F. Blake in Proc. Geol. Assoc., Vol. v. p. 232 *et seq.* (1878).

S.—Fossils collected by the Geological Survey, including those obtained by Mr. W. Hill in 1899.

St.—Fossils obtained by Mr. J. W. Stather, of Hull.

—	Zone of H. planus.	Micraster Zones.	Marsupite Zone.	Quadratus Zone.
Pisces.				
Scapanorhynchus raphiodon, *Ag.*	—	—	L	—
Cephalopoda.				
Ammonites [Desmoc.] pseudo-gardeni? *Schlüt.*	—	—	St	—
„ sp.	—	—	—	L
Hamites sp.	—	—	S St	—
Scaphites binodosus? *Roemer*	—	—	—	St*
„ inflatus? *Defr.*	—	—	—	L
Actinocamax granulatus, *Blainv.*	—	—	B S L St	B S L St
„ verus, *Miller*	—	—	B L St	B
Nautilus cf. darupensis *Schlüt.*	—	—	—	St
Gasteropoda.				
Pleurotomaria perspectiva, *Mant.*	—	M	St	—
Lamellibranchiata.				
Avicula tenuicosta, *Roemer*	—	—	M	—
„ sp.	—	—	—	St
Inoceramus Brongniarti, *Sow.*	—	M S	—	—
„ digitatus, *Sow.*	—	M	—	—
„ involutus, *Sow.*	—	M	—	—
„ lingua, *Goldf.*	—	—	B St	B St
„ mytiloides, *Sow.*	S	—	—	—
„ sp.	—	—	B	L
Lima Hoperi, *Sow.*	—	S	St	—
Ostrea acutirostris, *Nilss.*	—	S	S	—
„ vesicularis, *Lam.*	S	S	B S	—
„ sp.	S	—	S	B
Spondylus latus, *Sow.*	—	M	—	St
„ truncatus? *d'Orb.*	—	M	—	—

* Found at White Hill, near Bridlington.

—	Zone of H. planus.	Micraster Zones.	Marsupites Zone.	Quadratus Zone.
Brachiopoda.				
Crania egnabergensis, *Retz.*	—	—	St	—
Kingena lima, *Defr.*	S	—	St	—
Rhynchonella Cuvieri, *d'Orb.*	B		S?	
„ **limbata**, *Schloth.*	—	—	—	St
„ **plicatilis**, *Sow.*	S	—	B	B St
Terebratula carnea, *Sow.*	—	M	St	—
„ **sexradiata**, *Desl.* (=Kingena)	—	—	B	—
„ **semiglobosa**, *Sow.*	B S	S	B S St	B
Terebratulina striata, *Wahl.*	B S	—	—	St
Annelida.				
Serpula granulata, *Sow.*	—	—	St	—
Echinodermata.				
Bourgueticrinus ellipticus, *Miller*	—	—	B S St	B
„ sp.	B	—	—	—
Cardiaster ananchytis *Leske* (=granulosus)	—	—	—	L
„ (? new sp.)	—	—	—	St
Cidaris clavigera, *König*	—	—	St	—
„ hirudo, *Sorig.*	B	—	B	—
„ sceptrifera, *Mant.*	—	—	B St	St
„ subvesiculosa, *d'Orb.*	—	—	B	—
Cyphosoma Kœnigi, *Mant.*	—	—	B	—
„ radiatum, *Sorig.*	—	—	St	—
Echinocorys scutatus, *Leske*	B S	M S	B S St	B St
Holaster planus, *Mant.*	B S	—	—	—
Infulaster excentricus, *Forbes*	S?	—	—	St
„ rostratus, *Forbes*	—	—	L St	St
Marsupites testudinarius, *Schloth.*	—	—	B S L St	—
Micraster coranguinum, *Leske*	—	M	—	L?
„ cortestudinarium ? *Goldf.*	—	M	—	
„ Leskei, *Desm.* (=breviporus)	—	S	—	
„ præcursor, *Rowe*	—	S	—	
Offaster pillula, *Lam.*	—	—	M St	B
Pentagonaster (ossicles)	—	—	L St	St
Actinozoa.				
Caryophyllia cylindracea, *Reuss*	—	—	B	B
Parasmilia centralis, *Mant.*	—	—	B S St	
„ monilis, *E. & H.*	—	—	B	
Spongida.				
Bolospongia constricta, *Hinde*	—	—	—	H
„ globata, *Hinde*	—	—	—	H
Camerospongia capitata, *T. Smith*	—	—	B	S
Cœloptychium agaricoides, *Goldf.*	—	—	B	
Isoraphinia texta, *Roemer*	—	—	—	H
Jereica clava, *Lee*	—	—	S	H S
Manon marginatum, *Phil.*	—	—	—	S
Pachinion scriptum ? *Hinde*	—	—	—	S
Pachastrella convoluta, *Hinde*	—	—	—	H S
Phymatella reticulata, *Hinde*	—	—	—	H
Porosphæra globularis, *Phil.*	—	—	B S L St	St
„ pileolus, *Lam.*	—	—	S St	—
Scytalia fastigiata, *Lee*	—	—	—	H
„ radiciformis, *Phil.*	—	—	B L S	H?
„ terebrata, *Phil.*	—	—	—	H
Scyphia pedunculata, *Roemer*	—	—	—	S
Seliscothon explanatum, *Roemer*	—	—	—	H
„ planum, *Phil.*	—	—	—	H S
Stichophyma tumidum, *Hinde*	—	—	—	H S
Tethyopsis cretaceus, *Hinde*	—	—	—	H
Turonia variabilis, *Mich.*	—	—	—	H
Verruculina astrea, *Hinde*	—	—	—	H
„ miliaris, *Reuss*	—	—	—	H
„ papillata, *Hinde*	—	—	—	H
„ plicata, *Hinde*	—	—	S	H S
„ pustulosa, *Hinde*	—	—	—	H
„ Reussi, *McCoy*	—	—	—	H S
Ventriculites cribrosus, *Phil.*	—	—	—	H S
„ infundibuliformis, *S. Woodw.*	—	—	B	—
„ radiatus, *Mant.*	—	—	S	S

CHAPTER XXI.

THE UPPER CHALK IN FRANCE.

To give an account of the Upper Chalk of the Paris basin as a whole would of course be a great undertaking, and would occupy too much space; but in this chapter we propose to give brief accounts of the succession of beds to be found in the north-eastern and in the north-western parts of the Paris basin, in order to show that this succession is substantially the same as that which has been described in England.

Just as in 1876 Professor Barrois described the English Chalk from a French point of view, so now it will be interesting to regard from an English point of view those parts of the formation in France which correspond to our Upper Chalk. We shall thus see that whatever classification may ultimately be adopted it will be equally applicable to the North of France and to the South of England.

1. THE NORTH-EAST OF FRANCE.

Pas de Calais and Nord.—There is no cliff-section in the Pas de Calais comparable with that of the Kentish coast. The zone of *Holaster planus* comes into the top of the cliff at Cap Blanc Nez (see Vol. II Fig. 85), but the cliff ends at Sangatte, and the shore to the east of Calais is low and bordered by sand dunes.

According to Dr. Barrois,* hard rough chalk belonging to the zone of *Micraster cortestudinarium* is seen in the down above Blanc Nez cliff and at Setques, where it is quarried as a building stone. Still higher above Blanc Nez the zone of *M. coranguinum* comes in, and is also exposed in old pits north of Peuplingue, with the usual fossils, and is traceable southward into the Department du Nord.

Still higher beds are found to the west of St. Omer, and are referred by Professor Barrois to the zone of *Marsupites*, although no plates of that fossil have yet been found in them. He describes the chalk of this horizon as pure, soft, and white, with very few flints, and as containing among others the following fossils :—

Actinocamax verus.
Lima Hoperi.
Pecten nitidus.
Bourgueticrinus ellipticus.
Cidaris clavigera.
„ sceptrifera.
Echinoconus conicus.
Micraster coranguinum.

The chalk of the department of the Nord has been well described by M. Gosselet,* and more recently by L. Cayeux.† In the district of Cambresis the former divided this part of the formation into three bands :—

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* Proc. Geol. Assoc., Vol. vi. p. 30 (1879).

3. White chalk with conchoidal fracture.
2. Glauconitic chalk.
1. Chalk with horn-like flints (craie à cornus).

The "craie à cornus" is a soft white chalk containing many flints of irregular elongate shapes, lying both in layers and scattered through the mass. The principal fossils are *Ostrea sulcata* (*semiplana*), *O. hippopodium*, *Scaphites Geinitzi*, *Holaster planus*, and *Micraster breviporus* (=*Leskei*). "This chalk has a thickness of from 20 to 25 metres (65 to 80 feet) in the cantons of Quesnoy and Solesmes. . . . Near Valenciennes it has a thickness of 15 metres (49 feet), but only 8 or 9 metres at Wiers and Condé. In Flanders it crops out near Cysoing and Bouvines, but its thickness is not more than 1 metre (3 feet 3 inches).‡

The glauconitic chalk which overlies the "craie à cornus" in the Cambresis is a greyish chalk with glauconite grains and much phosphate of lime, either disseminated through it in small grains or occurring as nodules. At Avesnes les Aubert this bed has a thickness of six metres (20 feet), but it appears to thin out toward the north. M. Gosselet records the occurrence of *Micraster breviporus* and *M. cortestudinarium*, the latter ranging up into the overlying compact white chalk, the greater part of which probably belongs to the same zone.

Near Lille these beds are greatly reduced in thickness, and form part of a group which seems to have been formed in shallower water. Professor Barrois gives the following section at Annappes :—

		Feet.
	White chalk of Lezennes, etc. - - - - - - about	26
B	Glauconitic chalk with *M. cortestudinarium* in two beds each 5½ feet thick - - - - - - - -	11
	"Tun," a bed of yellow phosphatic nodules - - - -	2
A	Grey marls - - - - - - - - - - -	6½
	White "tun," a bed of whitish nodules - - - - -	2
	Marl with elongate flints - - - - - - -	1½
	Dièves with *Terebratulina gracilis*.	

The beds in the bracket A were regarded by Professor Barrois as the equivalent of his *M. breviporus* zone, which is nearly the equivalent of our zone of *Holaster planus*, and those in the bracket B as that belonging to the M. *cortestudinarium* zone. The white *tun* is not phosphatic, and he regarded it as equivalent to our Chalk Rock. The nodules of the upper *tun* contain 15 per cent. of phosphoric acid, and they are large, waterworn, and covered with Oysters, *Spondyli* and *Serpulæ*.

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* Descrip. géologique du Cambrèsis, Mem. Soc. d'emulation de Cambrai, 1865, and Esquisse géol. du nord de la France, p. 141, 18.

† Craie grise du Nord de la France. Ann. Soc. Géol. Nord. xvii. p. 105.

‡ Barrois, Terr. Cret. des Ardennes. Ann. Soc. Géol. Nord, T. v. p. 431.

The white chalk which is exposed near Lille and Lezennes has been described by Gosselet, Cheillouneix, Ortlieb, Barrois, and others. It was by them referred to the zone of *M. cortestudinarium*, but doubts were expressed by Professor Barrois in 1874, and in 1875* M. de Mercey wrote that the presence of *Inoceramus Mantelli*, *Inoc. involutus*, and *Belemnites subventricosus* suggested its being referable to the zone of *M. coranguinum*. This view was adopted by Professor Barrois in 1878,† though he maintained that both *M. coranguinum* and *M. cortestudinarium* occur in these beds.

Still more recently (1889) M. de Grossouvre has correlated this chalk of Lezennes with the lower part of the chalk of Villedieu, in Touraine,‡ and refers both of them to the higher part of the zone of *M. cortestudinarium*. He states that two characteristic species of *Ammonites* occur at both localities. One of these is *Am. tricarinatus, d'Orb*, and the other is a new species, which he has since described as *Am.* [*Peroniceras*] *Moureti*.

The chalk of Lezennes is described as soft, white, and homogeneous, with many black flints. Fossils are fairly common, including the teeth of many species of fish, and the following invertebrates :—

Ammonites peramplus.
„ Moureti.
„ tricarinatus.
Actinocamax westphalicus.
Inoceramus digitatus.
„ involutus.
„ Mantelli (? = latus)

Pecten cretosus.
Lima Hoperi.
Epiaster gibbus.
Echinoconus conicus.
Micraster cortestudinarium
Echinocorys gibbus.

Aisne, Marne, and Ardennes.—Throughout the eastern part of the Paris basin a band of chalk has been recognised by Professor Barrois and others under the name of the "craie à *Micraster breviporus*," and Barrois has found that it is everywhere divisible into two zones.

Of these two zones he says the lower (zone of *Holaster planus* maintains the same character throughout the whole region, but the upper (zone of *Epiaster brevis*) presents three distinct facies, which he describes under the names of the chalk of Rethel, the chalk of Chaumont Porcien, and the chalk of Vervins.

The zone of *Holaster planus* is everywhere a narrow band of hard and often nodular chalk, only a few feet in thickness, and recognised by Professor Barrois as the counterpart of what we know in England as the "Chalk Rock."

The upper division is from 100 to 130 feet thick, and its three facies are as follows :—

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* Ann. Soc. Géol. Nord, T. ii., p. 120 (1875).
† Ann. Soc. Géol. Nord, T. v, p. 468.
‡ Bull. Soc. Géol. de France, Ser. 3, T. xvii. p. 521.

1. The chalk of Vervins and Guise is described as soft, friable, greyish-white in colour, containing some disseminated silica and some fine argillaceous matter, and enclosing flints which are always black inside, with a white coating, and are very variable in shape, round, elongate, branched, or tuberculous, with a rough, irregular surface; they occur both scattered and in layers, and are of all sizes, from that of a small marble to large masses like our "Paramoudras." Fossils are abundant in this chalk, which is about 100 feet thick, and it has yielded many of the same species of Cephalopoda as those which occur in the German and English zone of *Heteroceras reussianum*. The following is a list of these:—

Nautilus sublævigatus.
„ Reussi.
Ammonites Neptuni.
„ peramplus.
„ cf. goupilianus.
Baculites bohemicus.
Scaphites Geinitzi.
„ auritus.
Heteroceras reussianum

2. The chalk of Chaumont-Porcien, further south, consists of greyish and whitish marls, some of which are argillaceous and sandy, containing flints of a bluish-grey colour, which adhere to the surrounding chalk like cherts. Fossils are not numerous, but include *Holaster planus*, *Micraster breviporus* (=*Leskei*), and allied species, *Terebratula hibernica*, and some common bivalves, but the only Cephalopod recorded is *Scaphites Geinitzi*.

3. The chalk of Rethel, in the country of the Rethelois and Champagne, is a mass of homogeneous white chalk, without flints and with few fossils, recalling in its general aspect the chalk of our English zone of *Terebratulina* rather than that which usually overlies the Chalk Rock. It has a thickness of about 40 metres (130 feet).

Prof. Barrois thought than in these departments of Aisne, Ardennes, and Marne there was no chalk which could be referred to the zone of *Micraster cortestudinarium*, but it has since been shown that his zone of *Epiaster brevis* corresponds to that of *M. cortestudinarium*, and this is directly succeeded by chalk which has the character and fauna of the *M. coranguinum* zone.

In the Ardennes the zone of *M. coranguinum* consists of soft white chalk without flints, but in the Aisne it passes into a hard white or yellow chalk containing siliceous nodules and intercalated beds of crystalline dolomitic sand.

Marsupites have not yet been found in these departments, though Prof. Barrois thinks the zone is represented in his "assise à *Micraster coranguinum*." Plates of *Marsupites* have, moreover, been found at Sens in the Yonne and at Beauvais in the Oise; and M. de Grossouvre informs me that they are associated with *Actinocamax verus*, *Act. granulatus* and *Act. Grossouvrei* (which has a very shallow alveolus, and is a variety of *Act. Toucasi*). Thus there is no doubt that the zone exists, though in some places its thickness may be very small.

The zone of *Actinocamax quadratus* was recognised by Hébert in 1863 at Epernay, Reims, Laon, and La Fere, and has since been traced by M. Peron, M. de Mercey, and others round the southern, eastern, and northern sides of the Tertiary basin of Paris, but has not yet been recognised to the eastward. As in England, it is characterised by *Actinocamax quadratus* and *Offaster pillula*, together with *Micraster glyphus*, *Scaphites constrictus*, and *Hamites carolinus*.

In Picardy a band of phosphatic chalk, similar to that of Taplow, occurs over a considerable area at the base of the zone of *Actinocamax quadratus*. It has been worked at Beauval, near Doullens, and near Hallencourt (Somme), as well as at Hardivilliers (Oise), and other places. The Doullens locality has been described by M. Lasne,* who gives the following succession :—

	Feet.
4. Soft white chalk with flints.	
3. Grey chalk with a nodular bed of rich phosphate at the base, *Act. quadratus* and *Act. verus* - - - -	20 to 80
2. Soft white chalk without flints - - - - - -	30
1. Chalk with many layers of flints, hard and nodular in the lower part - - - - - -	about 60

The lower beds (with flints) are regarded as belonging to the zone of *M. cortestudinarium*, so that No. 2 occupies the place of the *M. coranguinum* zone, and there would seem to have been contemporaneous current erosion, by which some thickness of chalk was carried away before the formation of No. 3.

M. de Grossouvre informs me that there has undoubtedly been such erosion, for the surface of the white chalk (No. 2) is hardened and perforated and covered with *Ostrea semiplana*. He has also pointed out that at Hardivilliers and other places three distinct horizons can be distinguished in the grey phosphatic chalk, as below in descending order :—

Chalk with *Act. quadratus* and *Bel. mucronata.*
„ „ *Act. quadratus* and *Offaster pillula.*
„ „ *Act. verus* and *Act. Grossouvrei* only.

and he regards the lowest of these as the equivalent of the zone of *Marsupites.*†

M. Lasne describes the grey chalk of Doullens as consisting of a white chalky paste, crowded with minute grains of brown phosphate of lime, all of which are derived from small organisms. A sample of the rock was also examined by Mr. Strahan,‡ who writes :—"The grains are, on the whole, larger and darker than those in the Taplow chalk, but they consist of foraminifera, prisms of Inoceramus-shell, bone fragments and oval pellets, and in all essential points the two deposits are identical. After treatment with acetic acid, this chalk furnishes remarkably beautiful specimens of phosphatised organisms."

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* Bull. Soc. Géol. France, Ser. 3, T. xviii. p. 441 (1890).
† See Bull. Soc. Géol. Fr. Ser. 3. t. xxii. p. 57, and t. xxvii. p. 132.
‡ Quart. Journ. Géol. Soc., Vol. xlvii. p. 362 (1891).

The zone of *Belemnitella mucronata* (or the chalk of Meudon, near Paris) does not occur continuously all round the border of the Tertiary area, but is recognisable along the valley of the Seine from Montereau to Villenauxe, and thence northward by Sezannes to Epernay.

It is perhaps in the department of the Yonne that the Upper Chalk of the Paris Basin is most fully developed, and it has been studied by M.M. Lambert and Peron.* Lambert divides the Senonian into an upper and lower stage, each comprising two substages and divisible into several zones which he indicates by letters instead of by special fossils. His scheme (including the Turonian) is as follows: —

Etages.	*Assises.*	*Zones.*	*Mètres.*
Senonien supérieur	à *Belemnitella mucronata*	P. and O.	30
	à *Actinocamax quadratus*	N. and M.	70
Senonien inférieur	à *Micraster coranguinum*	L.K.J.I.	70
	à *Micraster decipiens*	H.G.F.	80
Turonien	à *Micraster breviporus*	E.D.C.	70
	à *Inoceramus labiatus*	B.A.	60

The equivalent of our zone of *Holaster planus* is his zone E, which is 10 metres (33 feet) thick and yields *Scaphites Geinitzi*, *Holaster planus* and *Micr. breviporus* (= *Leskei*). The *Micraster* identified as *decipiens* (Bayle) is stated by M. Lambert to be the form generally known in England and France as *cortestudinarium*, but he regards it as distinct from that species which in his opinion has not yet been found out of Germany. Zone L. contains *Marsupites* and zone P. terminates in a hard limestone. It will be seen that the beds which correspond to our Upper Chalk have here a thickness of 260 metres (or 852 feet): borings near Paris seem to indicate a thickness of about 300 metres (or 980 feet).

2. THE NORTH-WEST OF FRANCE.

In dealing with this region it will be convenient to describe the beds which form the zones of *Holaster planus* and *Micraster cortestudinarium* in the first place, and then to give a brief account of those which represent the higher part of our Upper Chalk.

A. *The Lower Zones.*—These zones in their normal aspect are well exposed in the cliffs of the coast north-east of Fécamp, and have been described by Hébert.† Above the chalk with *Inoceramus labiatus* (which includes the zone of *Terebratulina*) comes chalk containing Cephalopods and *Holaster planus*; this has a thickness of 6 to 8 metres (20 to 25 feet). This is succeeded by the chalk with *Micraster cortestudinarium*, which forms the top of the cliff, but as the beds dip to the north-east they can be studied in detail and their thickness measured between Senneville and the *Petites Dalles*. This thickness is found to be 56 metres (=180 feet). He says that the upper limit of this chalk as seen at Veulette is an indurated surface perforated with tubules, and that this surface is cut obliquely across several of the beds of the *M. cortestudinarium* zone, so that the overlying chalk with zoned flints is actually unconformable to the beds below.

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* Lambert : Notice strat. sur l'étage Senonien des env. de Sens (1878); et Note sur la craie du dept. de l'Yonne, Bull. Soc. Géol. Fr. S. 3. t. vii. p. 202. (1879). Peron : Terr. de craie dans le S.E. du bassin anglo-parisien, Bull Soc. sc. hist. et nat. de l'Yonne (1887).

† Bull. Soc. Géol. de France, Ser. 3, T. iii. p. 520 (1875).

Hébert was also of opinion that the *M. cortestudinarium* chalk becomes rapidly thinner to the west of Fécamp, being only 15 metres (49 feet) at Yport, and only 4 metres (13 feet) at Etretat; but, as he elsewhere* states, that its thickness at St. Jouin, still further west, is 25 metres, there would seem to be some confusion between its real thickness at the intermediate places and the thickness of it which is actually seen above the beach. So far as I can ascertain, no one has yet re-examined the zonal divisions in this fine cliff section. Hébert mentions at Etretat a yellow sandy chalk passing into a sandstone (grès), and containing *M. cortestudinarium* in abundance. Mons. Lennier describes the lower beds exposed at Cap Antifer as " hard siliceous compact white chalk, with rolled green and yellow nodules and irregular veins of grey chalk." Evidently these resemble our Chalk Rock.

In the valley of the Seine near Rouen, and again at Villéquier, the zone of *Holaster planus* has quite the aspect of our Chalk Rock. The following is a description of the section exposed in a quarr near the top of St. Catherine's Hill at Rouen,† the measurements given in metres being translated into feet :—

	Ft.	*in.*
White chalk with a thin continuous seam of flint at base	20	0
Soft shaly white chalk - - - - - - - - -	4	0
Very hard nodular limestone with many fossils, *Am. prosperianus*, *Nautilus sublævigatus*, *Micraster breviporus*, *Rhynchonella plicatilis* - - - - - -	0	10
Chalk with loose nodules of hard chalk, and some black flints of elongate shape; *Micraster breviporus* - -	6	6
Beds of compact chalk with three layers of hard nodules, and two layers of flints; *Holaster planus* and *Micr. breviporus* - - - - - - - - - - -	13	8
Hard white nodular chalk, in two beds - - - -	7	6
Thin layer of marly chalk - - - - - - -	0	1½
Compact white chalk with scattered flints.		
Over	50	0

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* Bull. Soc. Géol. Norm., Vol. vi. p. 415.
† Bull. Soc. Géol. Norm., vol. vi., p. 387.

At Villéquier there were formerly large quarries, described by M. Lennier, from whose account the following is abridged :—

		Feet.
	Soft white chalk with layers of small cavernous flints.	
B	Firm white chalk with larger flints (*Bryozoa*) -	30
	Soft white chalk with many layers of small solid flints having long projections (*cornus*) - - - - -	26
	Alternations of hard (*bancs jaunes*) and soft chalk	42
	Soft chalk with solid flints and some continuous seams (*bizets*), and a hard yellowish layer in the lower part - - - - - - - - - -	33
	Continuous seam of flint.	
	Alternations of soft white chalk and hard yellowish gritty chalk - - - - - - - -	18
	Chalk with yellow and green nodules (? top of Chalk Rock) - - - - - - - - -	½
	About	150

Comparing this with the sections at Rouen and Fécamp, it would seem that the beds in the bracket B are referable to the zone of *M. cortestudinarium*, and have a thickness of about 130 feet, while the beds below may be referred to the zone of *Holaster planus*, the base of which was not exposed.

There seems to be little information about the country to the south of Villéquier and the south-west of Rouen, and when this part of the Chalk comes to the surface again in the valley of the Loire it presents a very different aspect. The Turonian succession of this district has been described in Volume II. of this memoir, and, according to M. de Grossouvre, the equivalent of the zone of *Holaster planus* and *M. breviporus* is a yellowish sandy and micaceous chalk, with a fauna of Bryozoa, Sponges, Echinoderms, and Oysters. Above this near Villedieu are hard white crystalline limestones, which are quarried at Ribochère to a depth of 4 metres (13 feet); these contain *Ammonites Noueli*, *Scaphites Geinitzi*, *Inoceramus Lamarcki*, *Acteonella crassa*, and many other fossils, and are considered by M. de Grossouvre to represent the northern zone of *Micraster cortestudinarium.**

B. *The Higher Zones.*—So far as we can ascertain, no more recent description of the cliff sections of Normandy exists than that of Hébert, published in 1875. No later paper is referred to by M. de Lapparent in the last edition of his Traité de Géologie (1900), and though Hébert did excellent pioneer work in zonal sub-division, a revision of the succession is much required. In the absence of this we can only refer to Hebert's account.†

Hébert divides the zone of *M. coranguinum* as seen in these cliffs into two parts or "assises": (1) Craie à silex zonés (chalk with banded flints), and (2) craie à silex noirs caries (chalk with cavernous black flints). The following notes are quoted from his account :— From Etretat to Fécamp the craie à silex zonés is nearly horizontal, and forms nearly the whole of the cliff from Yport to Fécamp; it contains *Cidaris perornata* and *Bryozoa* in abundance, but *Micraster coranguinum* is rare. The steps of Benouville afford an excellent section of this chalk, the thickness there seen being about 65 metres (213 feet), but the full amount may be 70 or 75 metres.

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* *Op. cit.*, p. 507 and Table on p. 522.

† Bull. Soc. Géol. de France, Ser. 3, T. iii., p. 512.

At Fécamp there is a powerful fault with a throw estimated by Hébert at 100 metres (328 feet), which brings up the Cenomanian, and carries the zone of *M. coranguinum* to the upper part of the cliff between that place and Senneville.

The higher division of this chalk can be seen in the southern cliff at Fécamp, but is not there accessible. It comes in again at Port Susette, near St. Valery, and forms the greater part of the cliff between there and Dieppe. He states that the junction of the chalk with banded flints and that of the chalk with cavernous flints is well seen east of St. Valery, and consists of a bed about 2 metres thick, without flints, soft in the lower part, very hard at the top, and pitted with tubular perforations. Above this the beds dip to the east, and the following succession comes in :—

		Mètres.
I.	Chalk with *M. coranguinum* and a layer of broken *Inocerami* one metre above the base and a hard bed at at the top (xx) - - - - - - - - - -	20
H.	Chalk with regular layers of flints, and a hard bed at the top (zz) - - - - - - - - - about	40
G.	Chalk with a hard bed at the top (ss) - - - - - -	9
F.	Chalk with many continuous layers of flint - - - -	40
E.	Chalk with flints and many *M. coranguinum* - - - -	28
D.	Hard bed at top of chalk with banded flints - - - -	2

Twelve metres above the hard bed (xx) three nodular bands are seen, which half-way between Pourville and Dieppe are about 30 or 32 metres above the beach. The cliff here is 91 metres high, so that above these bands there is nearly 60 metres of chalk which is not accessible. Fallen blocks, however, show that it consists of soft white chalk with small flints, and Hébert was unable to find any fossils in them; he remarks that it may belong to the *M. coranguinum* chalk, or possibly to the *Belemnitella* chalk. When he wrote the zone of *Marsupites* had not been established, and it seems very probable that some of this chalk with small flints belongs to the zone of *Marsupites* or Margate chalk.

If Hébert's estimates of thickness are correct, and there is no faulting, the total thickness of the chalk with cavernous flints will be 137 metres (450 feet), but he thinks there may be a fault with a throw of 80 metres at the Dun valley, and this would reduce the thickness to 187 feet, which is much more likely, and the whole zone of *M. coranguinum* would then be about 400 feet thick.

The chalk of the area to the south and south-west of Rouen has not yet been explored, but, as M de Lapparent remarks,* " When we pass from Normandy toward the south-west we find a gradual change takes place in the composition of the ' Emscherien ' (zones of *Micr. cortestudinarium, M. coranguinum,* and *Marsupites),* of the same kind as that affecting the Turonian and Cenomanian stages. It is at Villedieu, in the Loir et Cher, that this change becomes obvious. At this place yellow limestones make their appearance, which were formerly regarded as an exceptional facies of the basal portion of the Senonian, but M. de Grossouvre has shown that the different zones of the stage are represented in the succession, although their thickness is much diminished." This succession is as follows :—

Above the hard white limestone mentioned on p. 297 are marls often very glauconitic, and containing siliceous nodules; in these beds occur *Ammonites Emscheris, Micraster turonensis, Rhynchonella vespertilio, Ostrea proboscidea,* and *O. plicifera.* Bryozoa are also abundant. These beds are surmounted by a hard nodular sandy chalk, in which the commonest fossil is *Spondylus truncatus,* associated with

Ammonites syrtalis.
Nautilus Dekayi.
Baculites incurvatus
Lima marticensis

Vulsella turonensis.
Rhynchonella Eudesi.
Sphærulites Coquandi.
Salenia Bourgeoisi.

The highest member of the succession near Villedieu consists of chalk, full of large brown flints or cherts, which do not detach themselves from the surrounding rock. The thickness of these beds is from 20 to 25 feet, but fossils are rare in them ; they have yielded *Spondylus spinosus* and *Micraster Brongniarti.*

A connecting link between the chalk of Villedieu and that of Normandy is found at Chartres, where remains of *Marsupites* have been found associated with *Vulsella turonensis* in a chalk which M. de Grossouvre has shown to be a prolongation of the zone of *Am. syrtalis* and *Spondylus truncatus.*†

Since this chapter was written and printed, a detailed memoir has been published by the Administration of the " Carte Géologique detaillée de la France," written by M. de Grossouvre, and entitled "Recherches sur la craie·supérieure" (1901). In this treatise the author argues that the method hitherto employed in the zonal subdivision of the Chalk does not give satisfactory results. Owing partly to the varying facies of the deposits, and to the different vertical range which certain species have in different areas, he thinks that many mistakes have been with banded flints), and (2) craie à silex noirs caries (chalk with cavernous black flints). The following notes are quoted from his account :— From Etretat to Fécamp the craie à silex zonés is nearly horizontal, and forms nearly the whole of the cliff from Yport to Fécamp; it contains *Cidaris perornata* and *Bryozoa* in abundance, but *Micraster coranguinum* is rare. The steps of Benouville afford an excellent section of this chalk, the thickness there seen being about 65 metres (213 feet), but the full amount may be 70 or 75 metres.

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* Traité de Géologie, Quatr. Ed. (1900), p. 1365.

† La Craie de Chartres, Compte Rendu. Acad. Sci. Paris, 1892.

At Fécamp there is a powerful fault with a throw estimated by Hébert at 100 metres (328 feet), which brings up the Cenomanian, and carries the zone of *M. coranguinum* to the upper part of the cliff between that place and Senneville.

The higher division of this chalk can be seen in the southern cliff at Fécamp, but is not there accessible. It comes in again at Port Susette, near St. Valery, and forms the greater part of the cliff between there and Dieppe. He states that the junction of the chalk with banded flints and that of the chalk with cavernous flints is well seen east of St. Valery, and consists of a bed about 2 metres thick, without flints, soft in the lower part, very hard at the top, and pitted with tubular perforations. Above this the beds dip to the east, and the following succession comes in :—

		Mètres.
I.	Chalk with *M. coranguinum* and a layer of broken *Inocerami* one metre above the base and a hard bed at at the top (xx) - - - - - - - - - -	20
H.	Chalk with regular layers of flints, and a hard bed at the top (zz) - - - - - - - - - about	40
G.	Chalk with a hard bed at the top (ss) - - - - - -	9
F.	Chalk with many continuous layers of flint - - -	40
E.	Chalk with flints and many *M. coranguinum* - - -	28
D.	Hard bed at top of chalk with banded flints - - -	2

Twelve metres above the hard bed (xx) three nodular bands are seen, which half-way between Pourville and Dieppe are about 30 or 32 metres above the beach. The cliff here is 91 metres high, so that above these bands there is nearly 60 metres of chalk which is not accessible. Fallen blocks, however, show that it consists of soft white chalk with small flints, and Hébert was unable to find any fossils in them ; he remarks that it may belong to the *M. coranguinum* chalk, or possibly to the *Belemnitella* chalk. When he wrote the zone of *Marsupites* had not been established, and it seems very probable that some of this chalk with small flints belongs to the zone of *Marsupites* or Margate chalk.

If Hébert's estimates of thickness are correct, and there is no faulting, the total thickness of the chalk with cavernous flints will be 137 metres (450 feet), but he thinks there may be a fault with a throw of 80 metres at the Dun valley, and this would reduce the thickness to 187 feet, which is much more likely, and the whole zone of *M. coranguinum* would then be about 400 feet thick.

The chalk of the area to the south and south-west of Rouen has not yet been explored, but, as M de Lapparent remarks,* "When we pass from Normandy toward the south-west we find a gradual change takes place in the composition of the 'Emscherien' (zones of *Micr. cortestudinarium, M. coranguinum,* and *Marsupites*), of the same kind as that affecting the Turonian and Cenomanian stages. It is at Villedieu, in the Loir et Cher, that this change becomes obvious. At this place yellow limestones make their appearance, which were formerly regarded as an exceptional facies of the basal portion of the Senonian, but M. de Grossouvre has shown that the different zones of the stage are represented in the succession, although their thickness is much diminished." This succession is as follows:

Above the hard white limestone mentioned on p. 297 are marls often very glauconitic, and containing siliceous nodules; in these beds occur *Ammonites Emscheris, Micraster turonensis, Rhynchonella vespertilio, Ostrea proboscidea,* and *O. plicifera.* Bryozoa are also abundant. These beds are surmounted by a hard nodular sandy chalk, in which the commonest fossil is *Spondylus truncatus,* associated with

Ammonites syrtalis.	Vulsella turonensis.
Nautilus Dekayi.	Rhynchonella Eudesi.
Baculites incurvatus	Sphærulites Coquandi.
Lima marticensis	Salenia Bourgeoisi.

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* Traité de Géologie, Quatr. Ed. (1900), p. 1365.

† La Craie de Chartres, Compte Rendu. Acad. Sci. Paris, 1892.

			ZONES.	PARIS BASIN.	TOURAINE.
SENONIAN.	CAMPANIEN.	Upper.	Pachydiscus neubergicus	Chalk with *Bel. mucronata* of Meudon, Beauvais, Compiégne, Spernay and Montereau.	
			Hoplites Vari		
		Lower.	Mortoniceras delawarense	Chalk with *Act. quadratus* of Reims and Michery Chalk with *Offaster corculum.*	
			Placenticeras bidorsatum	Chalk with *Act. granulatus* of Margny des Compiegnes.	Craie de Blois.
	CORBIÉRIEN	Santonien.	Placenticeras syrtale	Chalk with *Marsupites.*	Chalk with *Spond. truncatus.*
			Mortoniceras texanum	Chalk near Dieppe.	Chalk with *Rhync. vespertilio.*
		Coniacien.	Mortoniceras Emscheris Barroisiceras Haberfellneri	Chalk with *Micraster coranguinum.* Upper part of the chalk with *Micr. decipiens.*	Beds with M. *turonensis* and *Ostrea proboscidea* Limestones of Villedieu and Cangey.
TURONIAN.		Angoumien.	Acanth. Deveriæ	Lower part of chalk with *M. decipiens.*	Chalk with *Ter. Bourgeoisi.*
			Acanth. ornatissimum	Chalk with M. *breviporus.*	Tuffeau de Poncé.
			Acanth. Bizeti	Chalk with *Ter. gracilis.*	Tuffeau de Bourré.
		Saumurien.	Mammites nodosoides	Chalk with *Inoc. labiatus,* nodular chalk of Blanc Nez and Diéves of Ardennes.	Tuffeau de Saumur.

With reference to this new zonal arrangement, he has been good enough to favour me with some further information, and to explain that he does not intend his table of Ammonite zones to take the place of the zonal classification which has been worked out in England and France, or of those established in other countries, and based on the prevalence of other kinds of fossils. To quote and translate his own words,—"the classification established by the evolution of the Ammonite-faunas represents in my opinion the ideal theoretical classification or standard for comparative purposes, to which all regional classifications should be referred for the purpose of correlating and synchronising the strata of different countries. . . . On the other hand, for the practical purpose of establishing the stratigraphy of the Cretaceous series of any given country, we shall be obliged to found it upon the study of the special fauna which the beds contain. Thus where *Micrasters* and *Echinocorys* are the predominant fossils, we must base our zones on the succession of different species of these Echinoderms; elsewhere the *Hippurites* or other shells may furnish the requisite data. But when the various local or regional classifications have been thus established and we wish to compare them with one another, then they can be referred to the standard stratigraphical scale which I propose to establish by means of the succession of Ammonite-faunas."

CHAPTER XXII.

THE MICROSCOPIC STRUCTURE AND COMPONENTS OF UPPER CHALK.

The base of the Upper Chalk is generally marked either by a bed or beds of hard yellowish semi-crystalline limestone with layers of green coated nodules, known as the Chalk Rock, or by chalk of irregular texture, hard crystalline lumps or nodules being enclosed in a softer mealy matrix and arranged in more or less defined layers. In Norfolk and north of the Wash these lithological characters are lost, and the lower beds of the Upper Chalk have little to distinguish them.

In the southern and south-eastern counties layers of rough nodular chalk, and sometimes beds of compact yellowish limestone, occur in some localities as high as the summit of the zone of *Micraster cortestudinarium*, but in Bedfordshire, Hertfordshire, and to the east and north-east the chalk above the Chalk Rock is firm and white without nodules. Above this, though its texture in mass varies slightly in different zones and in different localities, there is little variation in the aspect of Chalk from al- the higher zones. In the southern and south-eastern counties it is a white, dull, earthy limestone; in Lincolnshire and Yorkshire the Upper Chalk is much harder than that of the south.

THE CHALK ROCK AND ZONE OF HOLASTER PLANUS.

Macroscopic Aspect.—Though in the Thames Valley and in localities in Berks and Wilts the Chalk Rock occurs as a compact bed of limestone, it is also often a series of layers of hard rock separated by softer chalk. It exhibits a more or less nodular structure when smoothed hand-specimens are examined; this character seems to come on gradually in each bed from the base upward, and reaches its highest development in the green-coated calcareo-phosphatic nodules which often define the upper limit of each layer.

As in the case of the Melbourn Rock, there are all gradations from the well-marked nodule to one whose outline is scarcely perceptible, but the well-marked nodules of the Chalk Rock are nearly always slightly phosphatic, and there is frequently a brownish discoloration of the whole material.

Microscopic Aspect.

Structure of Typical Chalk Rock.—The structure exhibited in thin sections of Chalk Rock from Dorsetshire and Wiltshire, and from places along the main escarpment to Cambridgeshire, is so characteristic that it is hardly possible to mistake it for chalk from any other horizon.

The leading features are the abundance of Foraminifera, foraminiferal cells, and spheres, the number and variety of the coarser shell-particles, the presence of sponge-spicules and of large grains of glauconite. Amongst the fragments of calcareous organisms many pieces of plates, spines, or ossicles of Echinoderms can be recognised, together with *Inoceramus* prisms and fragments of other shells, while the varying structure of the other calcareous fragments suggests derivation from a variety of sources. Foraminifera occur in almost every section, the commonest being *Globigerinæ*, Textularians,* and nautiloid forms like *Cristellaria* and *Rotalia*. Hexactinellid sponge-mesh is frequently seen, while rod-like lengths, probably spicules of Monactinellid type abound, and here and there trifid forms can be made out.

Thus the coarser fragments of a variety of organisms together with grains of glauconite are intermingled in the calcareous matrix in ever-varying proportions, and give to the Chalk Rock a character not seen at any other horizon. There seems to be some evidence of current action, and a certain amount of sifting of the finest material from the coarser ingredients has taken place. Smoothed hand specimens of Chalk Rock, especially those taken a little distance from the top of each layer, will often show that the coarser particles lie in pipes, streaks, or mottlings which appear to divide incipient nodules, while nearer the top of the layer both nodules and matrix are more clearly marked. The nodules themselves appear to be hardened masses of chalk which has resisted this action, for they generally contain a smaller proportion of the coarse particles than the matrix in which they are now embedded ; on the other hand, it is possible to find a well-marked calcareo-phosphatic nodule which differs very little in its structure from the surrounding chalk.

The siliceous walls of all the sponge-spicules in the Chalk Rock have disappeared, and though they have sometimes been replaced by calcite, it frequently happens that the spicule is represented by a hollow space or cast. Nearly all specimens of Chalk Rock are full of minute holes, which appear to be casts of smaller spicules ; these vary in shape from perfectly round to an elongate oval, according to the angle at which the spicule has been cut.

A slice cut from the rocky chalk at the base of this zone at Pinhay, near Lyme, shows all the characteristics of Chalk Rock, the only special features being that sponge-spicules are very abundant, the Foraminifera in less variety and the glauconite grains smaller than usual.

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* By the term *Textularian* we mean to include not only species of *Textularia*, but also other forms such as *Gaudryina* which are difficult to distinguish from the former in section.

A rock-bed, having a striking resemblance to the Chalk Rock, occurs in the Broom Heath Railway cutting, about 4 miles west of Swaffham (Norfolk). It is a hard semi-crystalline limestone, and agrees fairly well with Chalk Rock, but contains no glauconite.

Nodular Chalk.—Where the Chalk Rock is absent, as in Kent, Surrey, and Sussex, and the zone of *H. planus* consists of rough, lumpy, and nodular chalk, the nodules near the base of the zone present a somewhat similar structure to that of the Chalk Rock, but there is less diversity in the appearance of the calcareous fragments, and they are also smaller; the plates and spines of Echinoderms still occur, but besides these the organic remains are chiefly "spheres" (which are very numerous), Foraminifera, and smallish shell-particles, which seem to be broken up Inoceramus-prisms. Sponge-spicules are, however, sometimes abundant, and in several sections prepared from the hard nodules of this zone, from Dover and Eastbourne, what appears to have been Hexactinellid mesh-work is of frequent occurrence.

Glauconite grains are often present in these nodules, but this mineral occurs far less frequently than in the Chalk Rock. Above the Chalk Rock, or within 10 or 15 feet above the base of the zone of *H. planus*, where Chalk Rock is not present, the microscopical features which characterise the base of this zone pass away, and the chalk assumes a more commonplace character, the recognisable coarser particles being chiefly spheres, with a few *Globigerinæ*, while the shell-fragments are chiefly *Inoceramus*-prisms, with here and there pieces, plates or spines of Echinoderms.

A specimen taken near the top of this zone at Dover was prepared to show both the nodule and the surrounding matrix. The nodule proved in this case to consist of a dense calcareous paste, now in a semi-crystalline condition, in which are outlined many minute "spheres," one or two *Globigerinæ*, and minute Textularians, with here and there a small shell-fragment. The surrounding matrix was full of Foraminifera and shelly particles, some of the latter being recognised as *Inoceramus*-prisms.

The Chalk in which *Holaster planus* has been found in Norfolk, Lincolnshire, and South Yorkshire, differs entirely in structure both from the Chalk Rock and from the nodular chalk of this zone. About 80–85 per cent. of it is amorphous calcareous material, with a few small weakly outlined "spheres" and here and there a *Globigerina* or a small shell-fragment.

The Chalk-Rock of the Winterbourne Valley West of Dorchester.—The remarkable exposures of this zone in the Winterbourne Valley, near Rew Farm and Winterbourne Abbas, have been described on p. 109, and as nothing quite like some of the beds there seen has been met with in any other part of England, they seem to merit special description. A set of samples from these quarries was handed to me by Mr. Jukes-Browne, and from an examination of them the following account has been drawn up:—

The Gritty Chalk (*Rew Farm*).—Thin sections of this chalk show that the greater part of the rock consists of Foraminifera, foraminiferal cells, and spheres, scattered amongst which are rather coarse fragments of *Inoceramus*-prisms, and other indeterminable shelly particles, a few pieces of echinodermal spines, plates, or ossicles, and here and there a sponge-spicule. In one place the cast of a fragment of hexactinellid mesh appears to be cut through. Large grains of quartz sand and of glauconite are distributed through the mass of the rock.

In another specimen taken near the top of the quarry these quartz grains are entirely absent and the chalk exhibits a structure which closely approaches that of ordinary Chalk Rock. The matrix contains many fragments of a variety of calcareous organisms, amongst which plates, spines, or ossicles of Echinoderms are conspicuous, together with other indeterminable shelly particles, all of which are of smallish size. The most abundant of the recognisable ingredients are, however, foraminiferal cells, spheres, and entire foraminifera, amongst which are *Globigerinæ*, *Textularia*, Rotalines, and some other obscure forms. Sponge spicules, long, thin, and needle-like, are rather numerous, and the rock is full of minute holes which appear to be casts of spicules; these are either perfectly round, and from this graduate to an elongated oval, according to the angle at which the spicule is cut in the section. All appear to be of monactinellid type, no trifid or hexactinellid forms were observed. There are also six or eight circular forms which may be referred to Radiolaria, and are similar to that figured in the Melbourne Rock. * The recognisable organic constituents form about 80 per cent. of the rock. A few small glauconitic grains occur in the section.

Winterbourne Abbas.—The hard rock in the quarry at this place (see p. 109) is, on the whole, similar to that of the upper part of the quarry at Rew Farm, and closely resembles Chalk Rock in structure. The recognisable ingredients which form about 70 per cent. of the mass, consist, as before, chiefly of foraminifera, cells, and "spheres," while smallish shell-fragments, such as broken *Inoceramus*-prisms, Echinodermal plates, etc., and other indeterminable shelly particles are scattered promiscuously through the rock. A few sponge-spicules occur and also a few of the forms with round outlines referred to above as Radiolaria.

In this rock, however, there occur small nodular inclusions of a totally different kind of material, which when examined in thin sections has all the characteristics of rock from the upper part of the Upper Greensand. Three of these nodules were separately examined.

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* See Quart. Jour. Geo. Soc., vol. li., p. 608. Pl. XXII., Fig. 2.

The first gave a section ¾ of an inch square, and proved to be a glauconitic sandstone. The sand grains are rather coarse, average about 3 mm. in longest diameter, and form about 55 per cent. of the mass. Glauconitic grains make about 25 per cent. more. There are one or two large shell-fragments, a few Foraminifera, and a large Echinodermal plate, or ossicle. The whole is compacted in a matrix of finely granular crystalline calcite; if any siliceous material is present it is masked. The nearest approach to the structure exhibited in this nodule is that of the sandy Chloritic Marl of Mupe Bay, the matrix of which is very similar to that of this inclusion, but the sand grains are coarser.

The second is a much smaller nodule and is surrounded by the chalky matrix. It is nearly of the same character as the last, but the matrix is more siliceous, and seems to consist largely of fine amorphous material neutral to polarised light—probably silicate of alumina. This nodule is sharply marked off from the surrounding chalk, and there is not the slightest evidence of a passage from one material to another. The slide, however, just takes in the edge of another nodule, which is not so well defined.

The third nodule differs a good deal from the preceding. It is very sharply marked from the matrix of chalk, and when viewed by transmitted light appears comparatively clear, though a confused and irregular crystalline structure can be discerned. Under crossed Nicols the crystals appear to be chiefly calcite, but silica can be clearly seen permeating the whole mass. The condition of the silica seems to be that of Chalcedony; a cryptocrystalline structure can be made out wherever the silica can be seen clear of the calcitic crystals. Much of the silica must have been originally in the globular colloid condition, for globules are still to be seen in many parts of the slide, but all are now in the chalcedonic stage. This nodule seems to contain very few sand grains; those visible are very small, though possibly some are obscured by the calcitic crystals. Nor are grains of glauconite abundant, they occur sparingly throughout the nodule; the elongate form of two or three of them suggests that they are short rod-like lengths, probably portions of a residuary spicular canal. No sponge-spicules are visible.

A thin section was also made from the gritty glauconitic chalk which is associated with the hard rock at Winterbourne Abbas, and this proves to be almost identical with the gritty chalk from Rew Farm; it contains even more quartz grains and large grains of glauconite are scattered throughout the rock.

Results of the Examinations of Washings.

Specimens of the Chalk-Rock and of the nodules of the chalk which occur at this horizon are so hard that it is useless to wash them, but the softer mealy matrix afforded material of interest. Samples of this material were obtained from Dover and Hitchin, and from the chalk containing *H. planus* at Enthorpe (South Yorkshire).

Shell-fragments.—The larger fragments of shell, especially in the Hitchin and Dover examples, were frequently so masked by the crystallisation of calcite upon them that in many cases their origin was uncertain; some, however, were pieces of the shell of *Inoceramus* showing the prismatic structure, while the finer particles were chiefly broken *Inoceramus*-prisms. Fragments of the tuberculated plates of *Micraster* could be distinguished in all specimens, most abundantly in those from Hitchin and Dover, and rather stout spines of Echinoderms broken into short lengths were of frequent occurrence.

The rounded ossicles of *Asteroidea* and the calcareous plates of an Ophiurid like those found in the Middle Chalk (see Volume II. p. 516), occurred frequently in the Hitchin and Dover specimens, though hardly in such abundance as in the Middle Chalk; at Enthorpe they were less common.

Both the Hitchin and Dover specimens contained many fragments of Bryozoa ; they were present also, though less numerously, at Enthorpe; in all cases, however, they were more abundant than in the Lower and Middle Chalk.

At Hitchin and Dover minute coprolites were very common, they were ovoid and elongate in shape, sometimes with annular ring-like markings, though usually smooth. These were not noticed in the Enthorpe specimen. Associated with the coprolites were fish teeth or particles of clear brownish material, having the structure of teeth or bone, and fragments of fish scales.

In this zone, at the Southerham quarry, near Lewes, there occurs a bed in which these minute coprolites are so very numerous that it has been called Phosphatic Chalk. This has been described by Mr. A. Strahan, and is similar to the deposit discovered at Taplow (Bucks) in 1891. The following remarks are condensed from his description.* The phosphatic chalk, he says, "consists of a white chalky matrix in which are embedded a multitude of brown grains." These "can be washed out in water, but the separation can be better effected by dilute acetic acid, which removes almost all the matrix, but scarcely corrodes the brown grains." The grains, which are the coprolites of small fish, consist largely of phosphate of lime, and amber-coloured chips occur, which are probably fragments of bone or fish teeth which occur in the bed. Prisms of *Inoceramus* are abundant, but the internal casts of Foraminifera form a large part of the residues. A thin section of the chalk shows the clear shells of Foraminifera surrounding the internal phosphatic casts. In a footnote he adds that the figure given on Plate XX., Fig. 2, of the Deep Sea Deposits, Challonger Reports closely represents the appearance of the organisms of the phosphatic chalk. The bed rests on a hard chalk floor, which in thin sections under the microscope is seen to consist of an amorphous calcareous paste enclosing numerous Foraminifera though not nearly in such abundance as in the phosphatic chalk. No foreign minerals were observed in this bed.

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*On a Phosphatic Chalk with Holaster planus at Lewes, Quart. Journ. Geol. Soc., Vol. lii. p. 463 (1896) with an Appendix by Mr. F. Chapman.

Sponge-Spicules.—Though many casts of sponge-spicules in glauconite occur in the residues of the rock at this horizon, no free siliceous spicules were found in the Chalk itself. From the evidence both of residues and thin sections sponges must have existed in considerable numbers, the siliceous walls of their spicules, however, in all cases which came under notice, have disappeared, and in many instances have been replaced by calcite. *Lithistid* spicules have not been definitely recognised, but *Monactinellid*, *Tetractinellid*, and *Hexactinellid* forms are represented.

Foraminifera.—These organisms are numerous in the mealy chalk of this zone. From the phosphatic chalk of Lewes, Mr. F. Chapman has already recorded 42 species and varieties (Op. cit. p. 270), and adding those isolated from our own washings and residues, also identified by Mr. Chapman, the total number of species from this zone will reach 66. They are distributed as follows:—

Families.	Genus.	Species.	
Miliolidæ ?	Miliolina ? - - -	1	
Astrorhizidæ	None - - -	None.	
Lituolidæ	Haplophragmium -	2	
	Ammodiscus - - -	2	
Textulariidæ	Textularia - - -	5	
	Verneuilina - -	1	
	Tritaxia - -	4	
	Spiroplecta- - -	1	
	Gaudryina- - -	5	
	Bulimina - - -	6	
	Pleurostomella - -	1	
Lagenidæ	Nodosaria - -	3	
	Rhabdogonium - -	1	
	Frondicularia - -	2	
	Marginulina- - -	2	
	Vaginulina- - -	1	
	Cristellaria- - -	8	One new species.
	Flabellina - -	1	
	Polymorphina - -	1	
	Ramulina - - -	2	
Globigerinidæ	Globigerina- - -	5	
Rotaliidæ	Discorbina- - -	1	
	Anomalina - -	2	
	Pulvinulina - -	2	
	Rotalia - -	3	
	Gypsina - - -	1	

The most persistent species are *Bulimina obtusa* and *Bulimina affinis*, which occurred in all specimens examined, and next to them were *Tritaxia tricarinata, Textularia turris, Cristellaria cultrata, Cristellaria gaultina, Globigerina marginata* and *Anomalina ammonoides*. *Pulvinulina micheliniana* was very common at Dover and Hitchin, but is not included in Mr. Chapman's list from Lewes. *Ammodiscus incertus* occurred in this zone in Norfolk, and in all specimens to the north-eastward, but in none of those to the south and westward. In the specimen from Dover the genus *Cristellaria* was poorly represented while in that from Hitchin five species occurred, including one new one, a large, handsome, well-marked form. From Lewes, Mr. Chapman records six species of *Cristellaria,* and among the other forms of the Rotaliidæ is *Gypsina cretæ,* a species recorded for the first time from the English Chalk (*op. cit.* p. 471.)

The Globigerinidæ, though common, are by no means abundant, and the individuals are less numerous than *Anomalina ammonoides* or *Pulvinulina micheliniana* in the Hitchin and Dover specimens. A complete list of the Foraminifera will be found on p. 349 *et seq.*

Ostracoda.—The valves of Ostracods were common, but not abundant, in this zone. With the addition of one species, *Cythereis auriculata,* from the phosphatic chalk of Lewes, the following is the list of forms obtained from the washings, and named by Mr. Chapman :—

Bairdia subdeltoidea (*Münster*)
" harrisiana (*Jones*).
Cythereis ornatissima (*Reuss*).
" auriculata (*Cornuel*).
Cytherella ovata (*Roemer*).
" obovata (*J. and H.*).
" Muensteri (*Roemer*).

All these have been found also in the Chalk Rock of Dunstable and Luton (see p. 229), and most of them range up from the Cambridge Greensand.*

Examination of the Residues.

Including three specimens analysed by Dr. Hume, there are recorded in the annexed table the results of eleven examples of the chalk of this zone after treatment with the acid solution. Five of these are typical specimens of the Chalk Rock, the five others are from localities where no definite and well marked rock beds occur in this zone, while that from the Isle of Wight is a specimen of the hard rocky chalk of the zone from Freshwater.

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* Annals and Magazine of Natural History, Ser. 7, Vol. ii. p. 346. (1898.)

The largest proportion of insoluble material is found in the specimens of Chalk Rock, viz., in that from the Vale of Wardour, 2·91 per cent.; from Medmenham, Buckinghamshire, 1·75 per cent.; Luton, Bedfordshire, 1·52 per cent.; Hitchin, Herts, ·881 per cent. These results show a gradual diminution of insoluble material from south-west to north-east along the main chalk escarpment. In the extreme south-west, however, at Pinhay Cliff, near Lyme, Dorset, an example of this zone only yielded a residue of ·685 per cent., another from Iwerne Hill, Blandford, ·763 per cent., but further south at the Isle of Wight the total amount of insoluble matter was 1·209 per cent.

Specimens of the nodular chalk of this zone from Eastbourne and Dover give results nearly alike, the residue being a little less than in Hertfordshire, but north of Hitchin a slight increase in the amount is observable, when a specimen from north-west Norfolk is compared with one from Hitchin, and a further increase occurs in Yorkshire.

The sample from Rew Farm, near Dorchester, has an exceptional amount of coarse residue, but putting this aside, the amount of coarse residue is larger in all specimens of the Chalk Rock than in the nodular chalks; this is chiefly due to the amount of glauconite and green matter contained in it, the quantity of detrital minerals being nowhere large, and only at Hitchin was the amount of fine sand a specially prominent feature; even here the amount is very small.

The only minerals recognised by Mr. Teall in the coarse residues of specimens of this zone were quartz and an alkali-felspar, but in the example from Norfolk (Great Bircham) garnet is noted in addition to these.

Dr. Hume, in a note on a sample of this zone from Pinhay Cliff, Lyme, (see p. 312) records muscovite mica and tourmaline. Compared with the *Terebratulina* zone there is some increase in the maximum size of the mineral grains, the largest ·72 mm., a single grain possibly of a somewhat exceptional size, occurred in the residue of the Isle of Wight specimen, the next largest, ·58 mm., being found in the specimen from the Vale of Wardour, the average size remains small.

Secondary Minerals.

Glauconite.—This mineral is very conspicuous in the Chalk Rock; the amount of it, judging by the eye, seems much greater than analysis proves to be the case, the dark grains showing strongly in contrast to the white chalk.

In an example of the Chalk Rock from Medmenham it was estimated that 70 per cent. of the coarse residue consisted of glauconitic grains, or about ·4 per cent. of the material examined. In another from Hitchin, 48 per cent. of the coarse residue consisted of glauconite, or ·14 per cent. of the whole material. A sample from Barford railway cutting, Vale of Wardour, contained still less, the amount of glauconitic grains being 55 per cent. of the coarse residue, or only ·11 per cent. of the material examined. In the two latter specimens, however, the place of the glauconite seems to be taken by the green-coloured amorphous matter described in Vol. II page 312, and which, in the Barford sample amounted to 25 per cent. of the coarse residue, or ·05 per cent. of the material examined.

The grains in the Medmenham specimen have rounded well-smoothed contours, the majority are dark green, a few are paler or have a sort of dusty pale green rind. Casts of Foraminifera, though common, are not extremely abundant, but some perfect ones occur. Rods of glauconite, presumably residuary spicular canals, are also common, but no well-formed recognisable casts of definite form were noticed.

In the Hitchin specimen the grains were more frequently in the form of casts of Foraminifera. Residuary spicular canals, either as simple rods or in well-marked tri-radiate forms, were frequent, and one or two fragments of very small Hexactinellid mesh occurred.

The grains of the sample from the Barford railway cutting were, for the most part, of quite a different stamp; a few rounded dark green ones occur, but the greater part are of a dull pale green colour and are casts of foraminiferal cells or of small Foraminifera. The more perfect casts were chiefly minute *Globigerinæ*, but many other species were noticed. Casts formed of the green mud noted above also occur commonly.

Residuary sponge-spicules are abundant, they were chiefly rods, but there were also a good many tri-radiate forms; no Hexactinellid mesh was observed.

Some of the grains in the Chalk Rock of Medmenham measured ·6 mm. in their longest diameter, the average being about ·27 mm., those from Hitchin were smaller, while in the rock from Barford one or two grains reached ·5 mm., the average, however, is not more than ·1 mm.

Besides glauconite there occurred in the Blandford and Isle of Wight specimens a number of nearly white grains of siliceous material which closely resemble those of glauconite in outline. The grains were rather small and of irregular shape, but a few were casts of small Foraminifera. One grain somewhat larger than the rest was observed to have a thin layer of green material, apparently glauconite, in its centre, the white matter occurring below and above.

In all the coarse residues irregular fragments of porous iron oxide occur. In the Enthorpe specimen minute spherules, red brown exteriorly, but with darker interiors, were found.

To sum up, therefore, the most noticeable points observable in the residues of the samples coming from the southern and central parts of England are as follows:—

1. The presence of glauconite grains in some abundance.

2. The larger amount of quartz in the form of fine sand.

3. The presence of some other detrital minerals—felspar, mica, tourmaline, and garnet.

The following note on a sample from the *Holaster planus* zone, Pinhay Cliff, Lyme-Regis, is by Dr. Hume:—

80·47 grammes of the rock yielded 552 grs. of insoluble residue,
=·686 per cent., divided into:—
Fine residue, ·541 grs.=·672 per cent.
Coarse residue, ·0115 grs.=·0143 per cent.
Hence the amount of CaCo=99·21 per cent.

The residue is almost entirely detrital in character, consisting of highly angular quartz grains, glauconitic rods (three forked ones in places), tourmaline (very small) ·06 mm. diam., muscovite mica, and opaque white masses having no definite organic form.

1. The quartz grains which form the greater part of this residue are in the main highly angular and very minute, a few larger grains, some of them tinted yellow, attaining a diameter of 25 mm. The majority of the grains are clear and transparent, but some of the larger ones are filled with innumerable gas cavities.

2. Muscovite mica is abundant in thin flattened flakes and easily recognised by the reflection from their surfaces in the dry powder.

3. Tourmaline occurs in minute blue grey fragments, showing no crystalline form, but occasionally displaying columnar structure. These are very small as stated above.

4. The glauconite rods are numerous, and evidently originated as internal casts of sponge spicules, a tri-radiate form being observed, though most of the examples were simple rods with flat terminations.

5. The larger chalcedonic fragments have no well defined form. The residue from this zone is very characteristic, especially as regards the presence of glauconitic rods, and is almost precisely identical with the residues from the same zone at Eastbourne and near Luton.

In the following table is shown, first the general composition of the samples analysed and next a more complete description of the coarse residues, as explained in Vol. II, p. 263.

TABULATION OF RESULTS. ZONE OF HOLASTER PLANUS.

Number.	Locality.	General Composition.						Composition of the Coarse Residue.										Remarks.
		Amount of Material.	Per cent. Soluble in Acid.	Per cent. of Coarse Residue.	Per cent. Fine Residue.	Total per cent. of Residue.	Colour.	Detrital Minerals.	Estimated per cent.	Maximum size of Grains.	Average size of Grains.	Secondary Minerals.	Estimated per cent.	Maximum size of Grains.	Average size of Grains.	Foraminifera.	Shell-fragments, indeterminable matter, etc.	
80	Dorsetshire. Pinhay, Lyme Regis*	gram's 80·47	99·21	·0143	·672	·686	—	Quartz, mica, tourmaline	—	mm ·25	mm —	—	—	mm —	mm —	—	—	The quartz of this residue highly angular, grains minute. Many glauconitic rods, probably residuary spicular canals of tri-radiate form, observed.
81	Blandford. Iwerne Hill	82·018	99·237	·206	·557	·763	Brownish grey	Quartz	1	·35	·11	Glauconite Whitish siliceous material. Iron oxide	50 30 3	·43 — —	·17 — —	None determinable (Shell-fragments) (Indeterminable)	— 5 10	This residue consisted largely of glauconite, much of which was in the form of foraminiferal casts, and residuary spicular canals, chiefly in rods or tri-radiate spicules, the latter abundant. It contained also a large proportion of whitish siliceous aggregations, not infrequently casts of Foraminifera, but usually irregular grains. Comparatively few mineral grains or iron oxide. Several fragments of silicified shell, and some remains of some very fragile arenaceous Foraminifera, apparently Bulimines. Percentages difficult to estimate.
2	Gritty chalk, Rew Farm.	99·419	95·429	3·480	1·091	4·571	Brownish grey	Quartz, felspar, ? ilmenite, zircon, rutile	64·8	3·0	·38	Glauconite Iron oxide	34·1 1.0	·97 —	·32 —	None —	— —	All the largest quartz grains were much rounded and worn. Amongst the larger grains of the coarse residue were noticed several siliceous fragments resembling small pieces of flint. The largest glauconite grains were of dark green colour, and differed somewhat from the grains usually found in the Chalk Rock. Some were highly polished as though worn. I think some must have been derived ? from Upper Greensand.

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* From notes by Dr. Hume.

TABULATION OF RESULTS. ZONE OF HOLASTER PLANUS—*continued*.

Number.	Locality.	General Composition.						Composition of the Coarse Residue.										Remarks.
		Amount of Material.	Per cent. Soluble in Acid.	Per cent. of Coarse Residue.	Per cent. Fine Residue.	Total per cent. Residue.	Colour.	Detrital Minerals.	Estimated per cent.	Maximum size of Grains.	Average size of Grains.	Secondary Minerals.	Estimated per cent.	Maximum size of Grains.	Average size of Grains.	Foraminifera.	Shell fragments, indeterminable matter, etc.	
83	Wiltshire. Barford Railway Cutting.	gram's 67·733	97·09	·20	2·71	2·91	Brownish grey	Quartz, alkali felspar	15	m m ·58	m m ·10	Glauconite Green matter Iron oxide	55 25 1	m m ·50 — —	m m ·09 — —	None (Shell-fragments and indeterminable matter)	4	The residue contained much green matter besides glauconite, both were largely in the form of casts of single foraminiferal cells. Residuary spicular canals, common, amongst which were many tri-radiate forms. A good deal of fine sand. A few fragments of silicified shell.
84	Isle of Wight. 20ft. above the black band—Freshwater.	96·454	98·791	·130	1·079	1·209	Brownish grey	Quartz - -	3	·72	·12*	Glauconite and white siliceous grains Iron oxide	35 1	·28 —	·11 —	None determinable (Shell-fragments and indeterminable matter)	61	There was a very large proportion of silicified shell fragments in the coarse residue: 60 per cent. by weight was separated by picking. The remainder was glauconite, largely foraminiferal casts and residuary spicules, rods and several tri-fid forms. There were also many spherules of the white material noted above. One quartz grain only of maximum size. There were some remains of some extremely frail arenaceous Foraminifera.
85	Eastbourne. Sussex - -	43·35	99·18	·034	·784	·818	—	—	—	—	—	—	—	—	—	—	—	Many residuary spicular canals in glauconite. (Shell fragments Foraminifera, cells and spheres, and other recognisable organic remains form about 70 per cent. of the rock at this horizon (own specimens).)
8	Kent. Dover - -	96·760	99·19	·011	·792	·803	Brownish grey	Quartz - -	1	·40	·19	Glauconite rare, Iron oxide	— 85	— —	— —	Ammodiscus (Silicified shell-fragments and siliceous nodules and indeterminable)	14	Two specimens of *Ammodiscus charoides* occurred in this residue. Limonite had encrusted some Hexaclinellid spongemesh, leaving a hollow cast. There was one large milky aggregation of chalcedony and several pieces of shell inter-prismatically silicified. (Recognisable organic remains form about 60 or 70 per cent. of the rock.)

* The large grain not included.

† From notes by Dr. Hume.

TABULATION OF RESULTS. ZONE OF HOLASTER PLANUS.

		General Composition.						Composition of the Coarse Residue.										
Number.	Locality.	Amount of Material.	Per cent. Soluble in Acid.	Per cent. of Coarse Residue	Per cent. of Fine Residue.	Total per cent. Residue.	Colour.	Detrital Minerals.	Estimated per cent.	Maximum size of grains.	Average size of grains.	Secondary Minerals.	Estimated per cent.	Maximum size of grains.	Average size of grains	Foraminifera.	Silicified shell-fragments, &c.	Remarks.
		gram's								mm	mm			m m	m m			
87	Buckinghamshire. Medmenham.	98·658	98·25	·580	1·17	1·75	Grey	Quartz, alkali felspar	2	.32	·11	Glauconite, Green matter, Iron oxide	7 15 1	58 —	·27 —	Bulimina, Silicified shell-fragments, etc., and indeterminable	— 12	The Glauconite largely as casts of Foraminifera and rod-like lengths, presumably spicular canals. No trifid forms or Hexactinellid mesh. Many thin siliceous flakes apparently silicified; shell-fragments, and milky-white siliceous aggregations—some resembling foraminiferal casts. (The recognisable organic remains form 75 to 80 per cent. of this rock, chiefly foraminiferal cells and spheres, a fragment of a Bryozoon, few Foraminifera or shell fragments.)
88	*Bedfordshire. Luton	80·29	98·47	·59	·929	1·52	—	—	—	—	—	—	—	—	—	—	—	
89	Herts. Hitchin	98·804	99·11	·295	·586	·881	Dark Brownish grey	Quartz, alkali felspar	16	·21	·06	Glauconite, Green matter, Iron oxide	43 33 1	— —	14 —	Ammodiscus (Indeterminable)	2	The green matter was greyer than in any of the preceding. The glauconite, as usual, in foraminiferal casts and residuary spicular canals, amongst which trifid forms were not uncommon. Hexactillenid mesh observed. A single specimen of *Ammodiscus*. Mineral grains rather numerous, but very small. (Recognisable organic remains, shell-fragments, Echinoid plates and spines, Foraminifera, cells, spheres, and sponge spicules about 70 to 75 per cent. of the rock.)
90	Norfolk. Great Bircham	83·048	99·05	·14	·929	·944	Brownish grey.	Quartz, alkali felspar, Garnet	—	·33	·09	Glauconite rare Iron oxide	—	—	1	Rhizammina, Ammodiscus, Gaudryina	—	More than half this residue consisted of mineral grains. Only two grains of glauconite were observed. No sponge spicules. Two rather large fragments of "mesh-work" occurred and several pieces of silicified shell. (Recognisable organic remains, chiefly foraminiferal cells, spheres, very few Foraminifera or shell-fragments, altogether about 40 per cent. of the chalk.)
	Yorkshire. Enthorpe	60·051	98·792	·008	1·20	1·208	Rather pale grey.	Quartz	—	·35	·09	Iron oxide	—	—	—	Rhizammina, Ammodiscus	—	The iron oxide occurred in minute spherules red-brown exteriorly, darker inside, all about the same size, viz., ·18 mm. (Foraminiferal cells and spheres, very few larger Foraminifera or shell-fragments form about 35 per cent. of the rock.)

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* From notes by Dr. Hume.

ZONE OF MICRASTER CORTESTUDINARIUM.

Microscopic aspect of thin Sections.

The chalk of this zone varies somewhat in its structure when viewed under the microscope in thin sections. Specimens from near Cruxton in Dorset, from Boreham Down, near Warminster, from Lewes (Sussex), from Dover and Chatham (Kent), and from Medmenham (Bucks), all contain a large proportion of shelly particles which in every case are of small size and appear to have been much broken up. In the specimens from the above-named localities these, with Foraminifera and "spheres," are estimated to form from 35 per cent. to 60 per cent. of the deposit. A sample of this zone from near Blandford only contains about 20 per cent. of the coarser ingredients, while two others from near Hitchin contain still less and consist chiefly of amorphous material; the recognisable organic remains in one being estimated at only 10 per cent., and in the other at about 15 per cent. Another sample, from Great Durnford, near Salisbury, is chiefly amorphous matter, with very few shell-fragments or foraminifera.

A specimen from Enthorpe in Yorkshire, contains a large number of minute calcareous particles, presumably of shell, "spheres," cells and the tests of Foraminifera forming with the shelly particles about 25 per cent. of the rock. In all specimens the walls of the "spheres," cells, and Foraminifera are as a whole weakly outlined. From evidence of the sections the families of the *Textularidæ* and *Globigerinidæ* are most frequently represented; the area occupied by foraminiferal tests is, however, never very large. In the Lewes, Dover, Chatham, Hitchin, and Enthorpe specimens fragments of Bryozoa have been cut through, while in nearly all of them echinodermal plates or ossicles can be observed. Sponge-spicules are entirely absent in the specimens already mentioned, but one from Cruxton in Dorset, contains traces of hexactinellid mesh, and the circular organisms (see p. 305), believed to be Radiolaria are also to be seen. Grains of glauconite are rare.

For examples of the beds of hard limestone which occur in this zone we may take the following:—

Kent, Chatham Hill.—Upper bed of yellowish rock by the side of the main road. This limestone when viewed as a thin section under the microscope is seen to be full of organisms. Minute "spheres" or foraminiferal cells are abundant, and a few larger Foraminifera occur. Minute calcareous particles are distributed throughout it, but only a few are sufficiently large to be identified. Some are *Inoceramus*-prisms, and one, judging by its outline, for all other structure is obliterated, is an ossicle of a starfish. Of the Foraminifera *Globigerinæ* are most abundant, and smallish Textularians, and other broken or indefinite forms, occur. The chief feature of the section, however, is the abundance of sponge-spicules; some of these appear to be of hexactinellid type, others are simple rods cut through at various angles. In every case the siliceous walls have disappeared and are replaced by calcite.

Surrey, Guildford.—A large quarry near "Monkshatch." This bed is very similar to the last described, but shell-fragments are more numerous, coarser than in the rock from Chatham Hill. There is rather more diversity also in their structure; many no doubt are derived from *Inoceramus*-shells, but some have outlines which indicate derivation from other sources. Sponge-spicules occur throughout the slide; they appear to be chiefly Hexactinellid type, but a few are simple rod-like forms. As before, the siliceous walls are replaced by calcite. There is a little glauconite in this specimen.

Dorset, near Maiden Newton.—This rock bed differs from the two previously described. Minute foraminiferal cells or "spheres" are very numerous, and form a considerable part of the rock.

There is a well-marked vein of coarse shell-fragments extending across this slide. Some of these appear to be the plates of Echinoderms, and a spine of some size is cut through; other fragments are pieces of *Inoceramus*-shell, showing its prismatic structure, and some free prisms. In the remainder of the section shelly particles are not very abundant.

There are a few rod-like sponge-spicules, and one of Trifid form is well displayed, but there is no Hexactinellid mesh. As usual, the siliceous walls are in all cases replaced by calcite.

The expression cells *or* "spheres" is used advisedly in describing the sections of the Upper Chalk. The minute bodies which appear in the thin sections do not all seem to be the well-marked simple spheres which are so abundant in the lower beds of the Chalk. The walls of these bodies at this horizon are always thin and weak, and the diameter of the cells less than those of the Lower and Middle Chalk. Though representatives of the true "spheres" are no doubt present, many of the cells seem to be the young of *Globigerina* or other Foraminifera.

Results of the Examination of Washings.

Specimens of this zone from Blandford in Dorset; Lewes in Sussex; Dover in Kent; Hitchin in Herts; and Enthorpe in Yorkshire, were washed with water and the coarser particles separated by levigation.

Shell-fragments.—The prisms of *Inoceramus* and fragments of the shell continue to be the most conspicuous of the Molluscan remains, though fragments of shell other than those of *Inoceramus* could be recognised.

Echinodermal plates and spines were frequent, and the calcareous plates and ossicles of crinoids or starfish occurred commonly.

Fragments of Bryozoa were very numerous, and formed a marked feature in the specimens from Lewes, Dover, Hitchin; these were rather less common in the Blandford example and in that from Enthorpe; though present they were not conspicuously abundant. Minute fish teeth and ovoid coprolites were noted in all the specimens, but were comparatively rare.

Foraminifera. Both in individuals and species Foraminifera were distinctly less numerous than in the zone below; the small number of species isolated induced us to re-examine the specimens, but without important result.

Families.	Genus.	No. of Species.
Miliolidæ - - - -	Miliolina - - -	1
Astrorhizidæ - - -	Rhizammina - - -	1
Lituolidæ - - - -	Haplophragmium - -	1
	Ammodiscus - - -	1
Textulariidæ - -	Textularia - - - -	4
	Verneuilina - - -	2
	Tritaxia - - - -	1
	Spiroplecta - - -	1
	Gaudryina - - -	3
	Bulimina - - - -	5
Lagenidæ - - - -	Lagena - - - -	1
	Cristellaria - - - -	6
	Ramulina - - - -	1
Globigerinidæ - - -	Globigerina - - -	2
Rotaliidæ - - - -	Truncatulina - - -	1
	Anomalina - - - -	1
	Pulvinulina - - -	1
	Rotalia - - - -	2

Pulvinulina micheliniana and *Anomalina ammonoides* are the only species which occurred in every washing, but *Bulimina brevis* and *Cristellaria cultrata* were found in four out of five specimens of this Chalk; all these were common and usually abundant forms. The scarcity of the Lagenidæ is somewhat remarkable; they are represented by three genera and eight species only, compared with nine genera and twenty-one species in the zone below, and six genera and fourteen species in the zone above.

Ostracoda.—The valves of Ostracods were common in the Dover specimen, less numerous in the others; the following species named by Mr. F. Chapman were isolated.

Bairdia subdeltoidea, *Münster.*
Cythereis ornatissima, var. nuda, *J. & H.*
„ „ var. paupera, *J. & H.*
Cytheropteron umbonatum (*Will.*).
Cytherella ovata (*Roem.*).
„ Muensteri (*Roem.*).
„ williamsoniana (*Jones*).
„ „ var. granulosa (*J. & H.*).

Examination of the Residues.

Eight examples of this zone have been treated with the acid solution; three of the results given are extracted from Dr. Hume's researches.

It will be observed for the first time that there is no sequence in these results. The highest percentage of insoluble material, 3·72 per cent., occurs in a specimen from Medmenham, Bucks, and this is almost equalled by another recorded by Dr. Hume from Swanage, Dorset. The lowest are from Lewes, Sussex, and Dover, Kent, ·664 per cent. and ·609 per cent. respectively; the sample from Enthorpe, Yorkshire, shows a slight decrease in the amount of insoluble matter compared with the zone of *H. planus* in this locality. The amount of the coarser particles is exceedingly small, mineral grains being very scarce.

In two residues, one from Blandford in Dorset, and one from Medmenham in Bucks, submitted to Mr. Teall, quartz and orthoclase were the only minerals recognised.

In an example from Ballard Hole, Punfield Cove, Dorset, Dr. Hume found quartz, apatite, felspar, and tourmaline.*

The mineral grains are a little smaller than in the lower zone, the maximum being ·58 mm. compared with ·72 mm. in the zone of *H. planus*, and the average ·08 mm. to ·11 mm. Iron oxide usually formed the greater part of that separated. It occurred frequently in the form of short cylinders, as well as in minute irregularly-shaped pieces. The Enthorpe specimen contained marcasite in small octahedral crystals, much oxidized yet still retaining their original form. This specimen also contained many arenaceous Foraminifera, chiefly *Ammodiscus* and the tubes of *Rhizammina* in short lengths. Arenaceous foraminifera were absent in all the other specimens except that of Lewes, in which two specimens of *Ammodiscus* occurred. Glauconite was rare in all samples.

The generalisations made by Dr. Hume on the chalk of the zone appear to be correct; they were:—

1. The almost total absence of glauconite grains and rods.
2. The consequent larger percentage of grains of quartz and felspar in the coarse residue.
3. The absence [or rarity] of arenaceous Foraminifera.

It will be noticed that the total amount of coarse residue is generally much less than in the zone of *H. planus*, but the quantity of quartz and felspar present is probably about the same.

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* Chemical and Micro-Mineralogical Researches, page 59.

TABULATION OF RESULTS. ZONE OF MICRASTER CORTESTUDINARIUM.

Number.	Locality.	General Composition.						Composition of the Coarse Residue.					Remarks.
		Amount of Material.	Per cent. Soluble in Acid.	Per cent. of Coarse Residue	Per cent. of Fine Residue.	Total per cent. Residue.	Colour.	Detrital Minerals.	Maximum size of grains.	Average size of grains.	Secondary Minerals.	Foraminifera.	
92	Dorsetshire. Stourpane, near Blandford.	gr'mes. 76·991	97·52	·05	2·43	2·48	Pale grey	Quartz	mm ·15	mm ·08	Glauconite, iron oxide.	A few indeterminable fragments.	About 85 per cent. of the coarse residue was iron oxide, two large cylindrical lengths weighing alone one third of this residue. Mineral grains about 8 per cent. A few rod-like lengths of glauconite. Hexactinellid sponge mesh was present, some fragments retaining their siliceous walls; but of others only casts in limonite remained. A few trifid spicules. The organic remains chiefly rather coarse shell-fragments (*Inoceramus* prisms); these, with Foraminifera, shells, and spheres form about 35 per cent. of the rock.)
93	*Swanage— No. 1	81·31	96·38	·08	3·53	3·61	Brown	Quartz, apatite, felspar.	·33	—	Glauconite (rare).	None	A few glauconitic spherules, or aggregations of this mineral, present, forming a minute percentage of the total residue. In the coarse residue quartz-grains are numerous and of various shapes, rounded and angular; some clear, but many show the characteristic fluid inclusions of granitic quartz.
	No. 2	80·93	98·54	·03	1·43	1·46	Brown	Tourmaline	—	—	—	—	
94	Sussex. Lewes	69·604	99·33	·001	·663	664	Pale grey	Quartz	·17	·07	Glauconite, iron oxide.	Ammodiscus	The coarse residue from this specimen is the smallest obtained. It consisted of two specimens of *Ammodiscus incertus*, about a dozen quartz grains, two small masses of iron oxide, and two short rods of glauconite with some indeterminable particles. (Finely divided shell-fragments, with a few larger pieces, Foraminifera, cells, and spheres, neither of the two latter abundant, form about 60 per cent. of the rock.)
95	Kent. †Dover	70·02	99·39	·003	·606	·609	—	—	—	—	—	—	
96	Bucks. Medmenham	83·703	96·27	·040	3·68	3·72	Pale grey	Quartz, orthoclase	·58	·10	Iron oxide	None	The coarse residue contained some rather large masses of iron oxide, and a number of indeterminable siliceous fragments which may be sponge remains. There were about a dozen mineral grains. (Finely comminuted shell-fragments, small Foraminifera, chiefly *Textularians*, and a a few *Globigerina*, with cells and spheres, make 75 per cent. of the rock.)
97	Herts. Hitchin	67·787	99·118	·002	·88	·882	Brownish grey	Quartz	·21	·06	Iron Oxide	Ammodiscus	The coarse residue consisted of one fragment of shell, silicified interprismatically, eight or ten mineral grains, and a few masses of iron oxide.
98	Yorkshire. Enthorpe	71·818	98·93	·013	1·06	1·07	Brownish grey	Quartz	·48	·10	Marcasite	Ammodiscus, Rhizammina.	Several specimens of *Ammodiscus*, with short tube-like lengths, ? *Rhizammina*, and some aggregations of minute quartz grains occurred in the coarse residue. The Marcasite, orignally in minute octahedral crystals, which are now much oxidized. A few minute grains of glauconite and rod-like lengths. Three flat fragments of silicified shell occurred. (Very few shell-fragments; Foraminifera, cells, and spheres form about 25 per cent. of the chalk.)

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* "Chemical and Micro-Mineralogical Researches," page 58.

† *Ibid*, page 68.

ZONE OF MICRASTER CORANGUINUM.

Microscopic aspect of thin sections.

Thin sections of the chalk of this zone show that it consists chiefly of amorphous material; in the majority of specimens the proportion of the ingredients which can be recognised as particles of shell and Foraminifera, whole or broken, are variously estimated from 5 per cent. to 15 per cent., of the mass though occasionally they exceed this amount.

Thus in examples obtained from Whitehill near Blandford, Odstock near Salisbury, Taplow in Buckinghamshire, St. Margaret's Bay near Dover, Knebworth in Hertfordshire, particles sufficiently large to be definitely recognised and presumably derived from shells, and Foraminifera in no case exceed 15 per cent. One from near Burling Gap, Eastbourne, contains an exceptional amount of shelly particles, these with Foraminifera forming about 35 per cent. of the rock; while in another from Charlton, near Salisbury, and probably near the base of the zone spheres and cells form half the chalk, shell fragments being rare. A series of specimens from this zone in the Isle of Wight may be described as follows:—

Base of the Zone.—Chiefly amorphous material. There are a good many "spheres" or foraminiferal cells, more than in any of the foregoing, two large *Globigerinæ* only occur in the section; one is a mere shadowy outline, in the other the shell of the test is better preserved, though it is broken and crushed. Very few small shell-fragments. The coarser particles and Foraminifera form here about 12 per cent. of the chalk.

Middle of the Zone.—This specimen contains more calcareous particles. These are not *Inoceramus*-prisms, but fragments of irregular shape. One large piece is of chambered structure, possibly a Bryozoon, and the outline of others suggests derivation from the same or a similar organism. Besides these larger fragments the chalk is rather full of minute particles, presumably shell. "Spheres" and foraminiferal cells are common, but there is not a single *Globigerina* in the whole section, though there are a few Textularians and one or two indefinite forms. The coarser particles and Foraminifera may be estimated about 25 per cent.

Upper part of the Zone.—Foraminiferal cells and spheres fairly numerous, three or four large sized *Globigerinæ* and one or two Textularians occur. There is one piece of a Bryozoon, and the section just takes in the edge of a large Echinoderm plate. Throughout the section, but more abundant in some places than in others, are thin, thread-like lines of crystalline calcite; they are of no great length, rarely they can be seen to bifurcate at one extremity; they are probably sponge-spicules.

At Culver cliff at or above the top of this zone there are four lines of green-coated nodules.* Specimens of these nodules were submitted to a microscopic examination, and were found to consist mainly of the fine amorphous material of the chalk with a somewhat unusual number of perfect Foraminifera; sponge-spicules are also present, their siliceous walls being replaced by calcite. The colouring matter appeared to be due to a green material which had accumulated in the interior of the foraminiferal cells, but the whole material was sometimes tinted green with no apparent change in its constituent particles. In some of the nodules were ramifying cylindrical perforations filled in with white material, which showed in strong relief against the remainder of the nodule.

In a specimen from Creake in Norfolk, probably from near the base of the zone, shell-fragments were more abundant than usual; a few *Inoceramus*-prisms occur, and many of the other particles, which are small and angular, are probably derived from the same shells. The Foraminifera visible are chiefly *Textularia* and a few well defined though minute *Globigerinæ*, with some other indefinite forms which cannot be identified in thin sections, together with single cells and "spheres." The area occupied by these organisms and particles of shell is about 20 per cent. of the Chalk.

A sample from Kirk Ella quarry, near Hull (Yorkshire), is probably just above the middle of the zone, but perhaps higher. In this specimen there are a few well-marked large *Globigerinæ* and *Textularia*, while those of minute size together with cells and "spheres" are fairly numerous. Very few shelly particles occur, but there are one or two portions of Echinodermal plates. Coarse particles, etc., about 20 per cent.

Results of the Examination of Washings.

The specimens of Chalk from this zone examined by washing were obtained from Quidhampton, Wiltshire (middle of the zone), Dover (near the base), Chatham (near the top), Hitchin (the centre), Rudham in West Norfolk (lower third).

Shell-fragments.—The quantity of shell-fragments separated from the finer material by levigation was less than in the zone below. They included *Inoceramus*-prisms, fragments apparently of *Pecten*, flat pieces of uncertain derivation and not infrequently minute specimens of *Terebratulina* or fragments of the shell. In the Upper Chalk many prisms of shell probably derived from *Inoceramus* differ from those of the Lower and Middle Chalk, they are usually larger, longer, more rounded in outline and generally less wedge shaped than the prisms met within the lower zones. From this zone upwards *Inoceramus*-prisms no longer form a conspicuous feature amongst the coarser particles obtained by washing. Echinodermal plates and spines occur sparingly, but the plates of Crinoids or Starfish were either absent or rare. Very few fragments of Bryozoa were seen.

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* Geology of the Isle of Wight, by C. Reid and A. Strahan, Mem. Geol. Survey, page 79 (1889). These nodules are most probably in the zone of *Marsupites*.

No fish teeth or coprolites occurred in any of the specimens from the localities above mentioned.

The two remarkable beds of phosphatic chalk discovered at Taplow, and described by Mr. Strahan,* belong either to this zone or to that of *Marsupites* (see p. 219). The upper one is 11 feet, and the lower 4 feet thick. Like that of Lewes (see p. 307) they are full of brown coprolites rich in phosphate of lime. They rest on floors of hard nodular rock into which the soft material of the overlying phosphatic chalk is piped.

Mr. Strahan describes the piped chalk as follows:—" A thin slice of the piped chalk from just below one of the brown beds shows white chalk traversed by tubes full of the brown powdery variety. The white chalk contains a few scattered Foraminifera, all imperfect. The test appears as a sharply defined clear layer, and encloses granular material resembling the matrix, or in some cases a crystalline substance, but in many instances is empty. Many of the foraminiferal chambers show a black cross . . . . presumably due to a radial structure of the test. The tubes mentioned are sharply defined and crowded with organisms, most of them filled entirely or partly with an opaque brown mineral."

The contents of the brown rock obtained by powdering are chiefly brown grains, which are without much doubt the excreta of small animals, pieces of fish teeth and bone, prisms of *Inoceramus*, etc., and many Foraminifera. The fine mud consists mainly of coccoliths [i.e., pseudococcoliths], discoliths, and rhabdoliths.

Foraminifera.—Foraminiferal tests were more numerous amongst the coarser particles of the washings than in the zone of *Micraster cortestudinarium*, and the phosphatic chalk of Taplow is very rich in Foraminifera.

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* On a Phosphatic Chalk with *Belemnitella quadrata*, at Taplow. Quart. Journ. Geol. Soc., Vol. xlvii. p. 356 (1891).

Mr. Chapman identified 51 species among those isolated from our washings, the following families and genera being represented:—

Families.	Gen.	No. of species.
Astrorhizidæ	Rhizammina	1
Lituolidæ	Reophax	1
	Haplophragmium	2
	Ammodiscus	1
Textulariidæ	Textularia	3
	Verneuilina	2
	Tritaxia	1
	Spiroplecta	1
	Gaudryina	3
	Bulimina	9
	Bolivina	1
Lagenidæ	Nodosaria	2
	Frondicularia	2
	Rhabdogonium	1
	Cristellaria	7
	Polymorphina	1
	Ramulina	1
Globigerinidæ	Globigerina	3
Rotaliidæ	Discorbina	1
	Truncatulina	3
	Anomalina	1
	Pulvinulina	1
	Rotalia	3

Of these 51 species the most persistent, *i.e.*, those which occur in every sample from this zone, are *Verneuilina triquetra*, *Bulimina brevis*, and *Bulimina obtusa*, *Cristellaria convergens*, *Ramulina aculeata*, *Truncatulina ungeriana*, *Anomalina ammonoides*, *Pulvinulina micheliniana*, and *Rotalia Soldani*.

Of these *Anomalina ammonoides*, *Verneuilina triquetra*, *Pulvinulina micheliniana*, *Rotalia Soldani* were most abundant. *Bulimina Presli*, a form not noticed before in the Upper Chalk, occurs rarely at Dover. For a complete list see p. 349.

Globigerinæ were rare everywhere and such as were isolated were minute and puny examples of the family. Arenaceous forms were generally rare or absent in the residues, but in that from Blandford the tubes of *Rhizammina* formed much of the insoluble material.

Ostracoda.—Valves of Ostracoda were present everywhere and the following forms were isolated from the washings and named by Mr. Chapman:—

Bairdia subdeltoidea, *Münster.*
Cythereis ornatissima, *Reuss.*
„ „ var. nuda, *J. & H.*
„ „ reticulata, *J. & H.*

Cytheropteron alatum, var. cornuta, *Bosquet.*
Cytherella ovata, *Roemer.*
„ obovata, *J. & H.*
„ Muensteri, *Roemer.*
„ williamsoniana, *Jones.*

No sponge-spicules occurred in the washings.

Examination of the Residues.

In the annexed list of six specimens of the Chalk of this zone subjected to treatment with the acid solution we include three by Dr. Hume.

It will be seen that the percentages of the insoluble material are again irregular and there is no sequence when the specimens are compared one with the other, but as a whole there is a smaller percentage than in the zone below.

The Norfolk sample is the purest chalk, giving only a residue of ·750 per cent., while that at Culver Cliff, Isle of Wight, contains 2·50 per cent. of insoluble matter, this sample, however, seems to be taken from the bed of green-coated nodules which occurs at or above the top of the zone in this locality.*

The percentages of the coarser particles is exceedingly small, the largest amount occurs in the specimen from Kirk Ella, Yorkshire, but this is due to the occurrence of fragments of silicified shell.

Detrital Minerals.—Grains of quartz and alkali felspar are the only minerals recognised, so few indeed are they that the whole of them could usually be counted. The average of the maximum size of the grains is the same as in the underlying zone, but the general average is larger. Three large grains in the Norfolk specimen, however, partly explain this.

Secondary Minerals.—Glauconite occurred only in two samples. Three rods, apparently residuary spicular canals, were noticed in the residue of the Blandford specimen and Dr. Hume records glauconitic rods and spherules in that from Culver Cliff.

Iron oxide occurs usually as minute spherules, brown exteriorly with darker centres, and not so frequently in the irregular shapeless masses which are met with in the lower zones.

In many residues of the Upper Chalk small irregularly-shaped masses of milky-white colour frequently occur. They are siliceous and when broken into fragments polarize with brilliant colours similar to chalcedony. They are not solid as a rule, but consist of irregularly shaped mammillated aggregations of silica firmly fused together.

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* Chemical and Micro-Mineralogical Researches, page 65.

Tabulation of Results. Zone of Micraster Coranguinum.

Number.	Locality.	General Composition.						Composition of the Coarse Residue.					Remarks.
		Amount of Material.	Per cent. Soluble in Acid.	Per cent. of Coarse Residue.	Per cent. of Fine Residue.	Total per cent. of Residue.	Colour.	Detrital Minerals.	Maximum size of Grains.	Average size of Grains.	Secondary Minerals.	Foraminifera.	
90	Dorsetshire. Blandford	grm's 58·945	98·810	·018	1·172	1·190	Rather pale grey	Quartz, alkali, felspar	mm. ·23	mm. ·10	Glauconite, iron oxide	Rhizammina? Ammodiscus, Haplophragmium	The greater part of the coarse residue consisted of arenaceous Foraminifera or their debris, estimated at 60 per cent.; mineral grains, estimated at 20 per cent., and iron oxide 10 per cent. of the coarse residue. There were also several rounded chalcedonic grains, apparently partly formed foraminiferal casts, three glauconitic rods, but no spicules. (No large Foraminifera or shell fragments occurred in a thin section of the rock, minute *Textularians*, and a few *Globigerinæ* with cells, and spheres form 10 per cent. of the rock.)
100	*Isle of Wight. Culver Cliff No. 1	81·40	97·50	·0036	2·49	2·50	Dull brown	Quartz	—	·03	Glauconite	—	The coarse residue consisted of broken organic fragments displaying no definite form. Aggregations of minute quartz grains occurred rarely, suggesting silicified foraminifera. Glauconite in the form of minute rods and spherules.
101	„ No. 2	76·64	98·49	·0026	1·51	1·51	—	—	—	—	—	—	
102	†Kent. Dover	73·72	98·80	·036	1·17	1·206	—	—	—	—	—	—	
103	Herts. Hitchin	79·888	97·842	·012	2·146	2·158	Pale grey	Quartz	·27	·09	Iron oxide	None	The coarse residue consisted almost entirely (90 per cent.) of small masses of porous iron oxide and a few aggregations of minute quartz grains, but no arenaceous Foraminifera could be identified. About a dozen mineral grains. (The recognisable organic constituents of this specimen seen in a thin section about 15 per cent., chiefly minute *Textularia*, but few small shell-fragments.)
104	Norfolk. Creake	68·030	99·25	·005	·745	·750	Brownish grey	Quartz, alkali, felspar	·34	·16	Iron oxide	Ammodiscus	There were only about 20 mineral grains in this residue, three of which—the largest—were cemented together by iron oxide. A single specimen of *Ammodiscus incertus* was the only Foraminifer noticed. One largish silicified fragment of an indeterminable organism. (The coarse organic particles form about 20 per cent. of this specimen, chiefly minute *Textularians*, with a few *Globigerina*. The shell-fragments scattered through the mass seem to be broken Inoceramus prisms.)
105	Yorkshire. Kirk Ella	93·837	98·868	·105	1·027	1·132	Brownish grey	Quartz	·46	·11	Iron oxide	Ammodiscus	The greater part of this residue consisted of silicified shell, Inoceramus prisms and flat fragments (77 per cent. of the coarse particles by weight). Two or three specimens of *Ammodiscus* occurred. About a dozen mineral grains. (Recognisable organic remains form about 20 per cent. of this specimen; they consist chiefly of minute *Textularians*, cells and a few spheres; shell-fragments not abundant, amongst them can be noted fragments of an Echinoderm.)

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* Chemical and Micro-Mineralogical Researches, pages 62 and 63.

† *Ibid.*

ZONE OF MARSUPITES.

Microscopic aspect of thin Sections.

The thin sections of the chalk of this zone which we have examined number only seven. The localities from which the samples were taken are Blandford in Dorset, Highfield near Salisbury, the Isle of Wight, Arundel in Sussex, Margate in Kent, and from the lower third of the flintless chalk from Flamborough, Yorkshire. All these specimens, and indeed those of the two succeeding zones, exhibited such a general resemblance in microscopical aspect that one description might almost serve for all.

The decrease in the amount of recognisable organic particles continues, the coarser material scarcely exceeding 10 per cent. of the mass in four out of the seven specimens. Of the three exceptions, the example from Highfield, holds about 15 per cent. of small shell-fragments and Foraminifera, that from Margate contains rather more shell-fragments, these with the foraminiferal cells, " spheres," and entire foraminifera, forming 15 to 20 per cent. of the mass. In the case of the flintless chalk of Yorkshire there are scarcely any shell-fragments, but foraminiferal cells and " spheres " are rather numerous.

Shell-fragments are very few in number and usually so small that it is impossible to suggest from the examination of thin sections whence they were derived. Very few recognisable *Globigerinæ* occur, in two of the slides there seem to be none; that of the flintless chalk contains three or four, and possibly some very minute forms which occur in the Blandford example may be referred to this genus.

Minute Textularians are to be seen in most of the sections. The few larger forms which occur are usually too indefinite for identification in section.

Results of the Examination of Washings.

Three specimens of this zone were broken up and washed with water, they were obtained from Blandford (Dorset), Arundel (Sussex), and Margate (Kent).

Shell-fragments.—*Inoceramus*-prisms of the long rounded type formed a considerable part of the calcareous particles, and were most numerous in the Margate and Arundel specimens Besides these, a few flat pieces and here and there a portion of a ribbed shell were noted. Rather large fragments of calcite often occur, not only at this horizon, but in most of the Upper Chalk zones; these sometimes can be made out to be fragments of *Inoceramus* and probably the thicker parts of other shells, but some seem to have no structure or if they have it is obscured by the redeposition of calcite.

Plates and spines of Echinoderms were common in the Arundel sample, in which also were noted ossicles of Asteroids and Crinoids, but in the other two specimens such fragments were of less frequent occurrence.

A few fragments of Bryozoa were noted in each sample.

The chalk of this zone from Arundel contained also minute ovoid coprolites, and clear amber coloured fragments which appeared to be either teeth or bone.

Foraminifera.—Though the list of forms is not so long as in some other zones, Foraminifera are individually abundant at this horizon at all the above localities.

The specimens isolated were named by Mr. Chapman, who found 40 species belonging to the following genera :—

Families.	Genus.	No. of Species.	——
Astrorhizidæ	Rhizammina - -	1	
Lituolidæ	Reophax - - -	1	New species.
	Haplophragmium -	2	One new species.
	Ammodiscus - -	2	
Textulariidæ	Textularia - -	2	
	Verneuilina -	2	
	Tritaxia - - -	1	
	Gaudryina - -	2	
—	Bulimina - - -	6	
	Pleurostomella - -	1	
Lagenidæ	Nodosaria - -	4	
	Flabellina - - -	1	
	Rhabdogonium - -	1	
	Marginulina -	1	
	Cristellaria -	2	
	Ramulina - - -	1	
Globigerinidæ	Globigerina - -	2	
Rotaliidæ	Truncatulina - -	3	
	Anomalina - -	1	
	Pulvinulina - -	2	
	Rotalia - - -	2	

Six of the species noted as most persistent in the zone below occur at this horizon in every specimen of the chalk examined, viz., *Verneuilina triquetra*, *Bulimina brevis*, *Truncatulina ungeriana*, *Anomalina ammonoides*, *Pulvinulina micheliniana*, and *Rotalia Soldani*. To these must be added another form (*Rotalia exsculpta*), which, from this point to the summit of the Chalk, is to be found in all specimens.

Anomalina ammonoides is exceedingly common in the zone of *Marsupites* Chalk, and the others though hardly so abundant occur with great frequency. The *Globigerinæ* as before are rare. For a complete list of the species, see p. 349.

Arenaceous forms were not found in any of the southern samples, but in the flintless Chalk of Yorkshire they recurred in some abundance. *Ammodiscus incertus* and *Rhizammina indivisa* were the most frequent, and the list includes a new species of *Reophax* and another of *Haplophragmium.*

The valves of Ostracoda seemed rather more abundant amongst the coarser particles and the following were isolated from the washings and named by Mr. Chapman :—

Pontocypris bosquetiana, *Reuss*
Bairdia subdeltoidea, *Münster*
Cythere (species).
Cythereis ornatissima, var. paupera, *J. & H.*
Cytheropteron concentricum, *Reuss* var. virginea, *Jones*
„ umbonatum, *Will.*
Cytherella ovata, *Roemer*
„ obovata, *J. & H.*
„ williamsoniana, var. granulosa, *Jones*
„ Muensteri, *Roemer*

Examination of the Residues.

Four specimens of this zone were treated with the acid solution. The results of three of these call for no special remark. They are all very pure chalks containing less than 1¼ per cent. of insoluble material. The coarse residue separated from the fine clay was very minute in quantity, and consisted of a few quartz grains, the average size of those measured being ·07 mm., and spherules or particles of iron oxide.*

In the fourth example, that of the flintless chalk, from near Flamborough, Yorkshire, the insoluble residue, chiefly fine clay, reaches 3·120 per cent., an amount exceeded in two cases only above the horizon of *Holaster planus.* It seems at first sight exceptional both for the horizon and the locality, but this increase of clayey matter in the highest beds of the Yorkshire Chalk is confirmed by the analysis of the specimen from the overlying zone. The coarser part of the residue of the flintless chalk consisted largely of the debris of arenaceous Foraminifera, and no less than six different species were isolated from it. Amongst the mineral grains in this specimen Mr. Teall recognises quartz and microcline felspar.

Secondary Minerals.—Glauconite is rare. Iron oxide frequently occurs in minute spherules.

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* Dr. Hume analysed a sample taken from the base of the pinnacles "just outside Studland Bay" on the Dorset coast (see Chemical and Micro-Mineralogical Researches, p. 65), believing this to be in the zone of *Marsupites*, but Dr. Rowe has shown that it must be in the zone of *Bel. mucronata.*

TABULATION OF RESULTS. ZONE OF MARSUPITES.

Number.	Locality.	General Composition.						Composition of the Coarse Residue.					Remarks.
		Amount of Material.	Per cent. Soluble in Acid.	P er cent. of Coarse Residue.	Per cent. of Fine Residue.	Total per cent. Residue.	Colour.	Detrital Minerals.	Maximum size of Grains.	Average Size of Grains.	Secondary Minerals.	Foraminifera.	
		grm's.							mm.	mm.			
106	Dorsetshire. Blandford -	24·437	98·90	·001	1·10	1·101	Pale grey	Quartz -	·14	—	Glauconite, Iron oxide	None - -	The coarse residue of this specimen consisted of about a dozen quartz grains, four fragments of iron oxide, and three minute grains of glauconite, with a little indeterminable material. (Recognisable organic ingredients, chiefly minute Textularians and cells, with a few shell-fragments not exceeding 10 per cent. in all.)
107	Sussex. Arundel - -	52·439	98·75	·003	1·240	1·243	Pale grey	Quartz ? felspar	·19	·08	Iron oxide	None - -	The coarse residue of this specimen consisted of nine grains of quartz and one of milky-white appearance, probably flspar ; a few minute spherules of iron oxide, and one rather large chalcedonic concretion. (Foraminifera, cells, and finely divided shell-fragments, less than 10 per cent. of the rock.)
108	Kent. Margate - -	86·491	99 012	·003	·988	·991	Grey -	Quartz -	·16	·07	Marcasite, Iron oxide, Glauconite	None - -	Marcasite occurred in well-marked octahedral crystals, somewhat oxidized ; two or three minute spherules of glauconite were noted, and a piece of shell inter-prismatically silicified. Very few mineral grains. (Shell-fragments, cells, a few spheres and minute Fora minifera, 15 per cent. of the rock.)
109	Yorkshire. Flintless chalk, lower third.	84·530	96·88	·020	3·10	3·120	Pale grey	Quartz -	·17	·06	Glauconite -	Rhizammina, Reophax, Ammodiscus, Haplophragmium	The coarse residue was chiefly the debris of arenaceous Foraminifera, amongst which tubes of *Rhizammina* were most abundant. Several fragments of Hexactinellid mesh. Iron oxide was in the form of irregular masses and minute spherules. About a dozen glauconitic grains, and the same number of quartz. (Recognisable organic constituents chiefly foraminiferal cells, with minute Textularians and a few *Globigerinæ*, but few shell-fragments ; altogether forming 20 per cent. of the rock.)

ZONE OF ACTINOCAMAX QUADRATUS.

Microscopical aspect of thin sections.

The specimens of this zone were nearly all obtained from the South of England, and chiefly from the neighbourhood of Salisbury, viz., three from Britford, Whaddon, and Milford;* one other was taken from Culver Cliff, about 70 feet above the flintless zone. They are all much alike and consist largely of amorphous material with foraminiferal cells and "spheres," the latter being rather more numerous than in the zone below. A few minute *Textularia* and nautiloid forms may be detected in each slide, and occasionally the tests of the larger forms of Foraminifera, which washings show to occur, are cut through in section, but are not identifiable. *Globigerinæ* are rare. In one of the Britford specimens (collected by Mr. Jukes-Browne) thin, thread-like sponge-spicules occur; one form is trifid and another appears to be part of Hexactinellid mesh. They are all rather obscure. The shell-fragments are small, and appear to be pieces of thin shell; only very few suggest derivation from *Inoceramus.* Here and there a small fragment of Echinoid test occurs. The amount of shell-fragments, foraminiferal cells and Spheres ranges from 15 to 20 per cent.

An example of this zone from the highest chalk in Yorkshire, near Bridlington, presents a very similar aspect, though there are fewer shell-fragments. Cells and Spheres are numerous and there are two or three trifid spicules. The amount of the coarse particles is estimated about 15 per cent.

The Examination of Washings.

Specimens of the zone from localities above noted near Salisbury and that from the Isle of Wight were washed with water. That from Yorkshire is hard and semi-crystalline and washing it was not attempted.

Shell-fragments.—The observation made with regard to the shell-fragments in the examination of the sections was verified in the washings. They proved to be for the most part thin, irregularly shaped pieces, the origin of which is doubtful. *Inoceramus* prisms were not numerous. Crinoid ossicles, Echinoid spines in short lengths, and here and there a single fragment of Bryozoon was noted.

No sponge-spicules were recognised in the washings.

Foraminifera.—These organisms appear to be less abundant in this zone than in any other, so far as our examination has gone.

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* Specimens of the upper and lower part of the zone were kindly sent by Dr. Blackmore at the request of Dr. Rowe.

Those obtained from our washings were named by Mr. F. Chapman and number only thirty species and varieties, three of which, a *Tritaxia*, a *Bulimina* and a *Bolivina*, are new to science.

Families.	Genus.	No. of Species.	——
Astrorhizidæ -	Rhizammina - -	3	
Lituolidæ - -	Ammodiscus - -	1	
Textulariidæ -	Textularia - - -	2	
	Verneuilina - -	1	
	Tritaxia - - -	1	One new species.
	Bulimina - - -	6	One new species.
	Bolivina - - -	2	One new species.
	Pleurostomella - -	1	
Lagenidæ -	Lagena - - -	1	
	Cristellaria - -	4	
	Polymorphina - -	1	
Globigerinidæ -	Truncatulina - -	1	
Rotaliidæ - -	Anomalina - -	1	One abnormal.
	Pulvinulina - -	2	
	Rotalia - - -	3	

Ammodiscus incertus occurred in all the acid residues of this zone. The absence or rarity of *Nodosaria* and *Globigerina* is curious. *Verneuilina triquetra*, *Bulimina brevis*, and *B. obtusa*, *Cristellaria rotulata*, *Truncatulina ungeriana*, *Anomalina ammonoides*, *Pulvinulina micheliniana*, *Rotalia exsculpta* and *R. Soldani* with its variety, *nitida*, are amongst the commonest forms. The most interesting is, perhaps, *Rhizammina algæformis*, which Mr. Chapman recognises in the acid residue from the Yorkshire example, and recorded for the first time from the chalk.

This form is described by Dr. Brady thus:* — "Test free, tubular, branching dichotomously, flexible, forming tangled weed-like tufts of indefinite size. Texture chitino-arenaceous, rough externally." "Specimens of this species were obtained by Dr. Carpenter, in 1869, in the deepest portion of the Atlantic explored by the Porcupine Expedition of that year." But at one of the Challenger stations off the western coast of South America, about the latitude of Valparaiso, the principal part of the contents of the dredge consisted of a weed-like organism of this sort. "At first sight the tangled threads bear considerable resemblance to masses of some Melanospermous Alga."

The depth of water where this form occurred so abundantly was 2,160 fathoms, but it appears to range from 2,900 fathoms in the North Pacific to 210 fathoms near the Fiji Islands.

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* Report of the Foraminifera dredged by the Challenger Expedition, p. 274.

Ostracoda.—But few valves occurred in the washings of this zone. The following were named by Mr. Chapman:—

Bairdia subdeltoidea, *Münst.*
Cythereis lonsdaleana, *Jones*
Cytherella ovata, *Roemer*

Examination of the Residues.

Little can be said in regard to the residues. The Salisbury specimens are amongst the purest chalks examined. The specimen from Culver Cliff was remarkable from the number of arenaceous Foraminifera it contained. The increase in the amount of clayey matter in the north continues through this zone, the analysis showing a slightly larger percentage of insoluble residue. As before, the coarser part of this residue consists chiefly of arenaceous Foraminifera, *Rhizammina* and *Ammodiscus* being the prominent forms.

The only mineral grains recognised were of quartz. These occurred in all residues, but were nowhere numerous. Some of the grains observed were larger than any seen in the zone of *Marsupites*, but the average size is nearly the same, viz., ·08 mm. Glauconite is entirely absent. The coarse residue, as usual, consists chiefly of small fragments of iron oxide.

TABULATION OF RESULTS. ZONE OF ACTINOCAMAX QUADRATUS.

Number.	Locality.	General Composition.						Composition of the Coarse Residue.					Remarks.
		Amount of Material.	Per cent. Soluble in Acid.	Per cent. of Coarse Residue.	Per cent. of Fine Residue.	Total per cent. Residue.	Colour.	Detrital Minerals.	Maximum Size of Grains.	Average Size of Grains.	Secondary Minerals.	Foraminifera.	
110	Dorsetshire. Whaddon	gr'mes. 39·477	99·318	·001	·686	·687	Grey	Quartz	mm. ·11	mm. ·08	Iron oxide -	Ammodiscus -	The coarse residue consisted of six or eight mineral grains and a few minute spherules of iron oxide. There were also four small globules of amber-coloured material somewhat similar to those met with in the Lower Chalk, and one small chalcedonic aggregation. (Cells, spheres, and minute Textularians with a few Rotaline forms, with finely comminuted shell-fragments form about 20 per cent. of this specimen.)
111	Wilts. Milford, Salisbury	69·412	99·393	—	·607	·607	Grey	Quartz	·13	·06	Iron oxide -	Ammodiscus	There were only half-a-dozen minute mineral grains in this residue, with two small masses of porous iron oxide. (Foraminifera, cells, a few spheres and small shell-fragments 10 per cent.)
112	Isle of Wight. Culver Cliff	107·894	99·274	·006	·747	·753	Grey	Quartz	·29	·10	—	Rhizammina, Ammodiscus, Haplophragmium, Bulimina	Arenaceous Foraminifera abundant in this residue, but more than half of it consisted of masses of iron oxide; but few mineral grains were present; no glauconite. (Cells, spheres, minute foraminiferal form about 20 per cent. of the rock.)
113	Yorkshire. Bridlington	87·163	96·719	·053	3·228	3·281	Pale grey	Quartz, microcline	·40	·09	—	Rhizammina, Ammodiscus, Bulimina	Arenaceous Foraminifera formed about half this coarse residue; they consisted chiefly of short lengths of *Rhizammina* and *Ammodiscus*. Bulimines rare. Two fragments of Hexactinellid mesh occurred, and two rather large pieces of silicified shell. There were also a few minute spherules of glauconite. Mineral grains more abundant than in the other specimens of this zone. (Recognisable organic ingredients chiefly cells, spheres, minute Foraminifera and small shell-fragments 15 per cent.)

ZONE OF BELEMNITELLA MUCRONATA.

Microscopic Aspect.

The chalk of this zone, like that underlying it, consists chiefly of amorphous calcareous material. Seven slides were prepared.

Specimens from Dorset contain only a few small shell-fragments' but Foraminifera, cells, and "spheres" are fairly numerous, minute Textularians being especially abundant. One or two nautiloid forms can be made out, the remainder have a vague outline, and give no clue to family or species. The area occupied by these forms, together with the shell-fragments, may be estimated from 10 to 20 per cent., but it must be remembered that the tests are themselves full of fine amorphous material.

Two specimens from Salisbury, kindly sent by Dr. Blackmore, are also chiefly amorphous matter, and contain a very small proportion of fine shelly fragments. Minute Textularians and globular forms which may be minute *Globigerinæ*, with here and there a larger test are scattered thinly through the chalk. Neither cells nor "spheres" are common, the total amount of recognisable particles and Foraminifera cannot exceed 10 to 12 per cent. In a third specimen, however, both cells and "spheres" are rather numerous.

Three specimens from the Isle of Wight, *i.e.* from Ashey Down, Culver Cliff, and Newport, all contain a larger percentage of shell-fragments, and recognisable organic fragments are more numerous in the deposit. The shell-fragments are rather small and thin, and though particles evidently derived from the shells of *Inoceramus* are present they are not numerous. Fragments of Echinoderms are present in all specimens, and in two out of three portions of Bryozoa have been sliced through. Cells, "spheres," and Foraminifera are thinly scattered throughout the rock; these, with shell-fragments, may be estimated to form 20 to 30 per cent. of it.

The specimen from Norwich is remarkable for the number of Foraminifera it contains. These are chiefly small *Textularia*, probably *T. globulosa*, but *Globigerinæ* also occur. They are somewhat unevenly distributed, and occur in veins or patches; in some parts of the specimen examined they form from 20 to 30 per cent. of the chalk, while in others they are far less numerous.

No sponge-spicules were observed in any of the sections of chalk from this zone.

Results of the Examination of Washings.

The four specimens of chalk of this zone broken up and washed with water were from Salisbury, Dorchester, the Isle of Wight and Norwich;[*] the results were not of great interest, but serve to confirm opinions formed in the examination of thin sections.

Shell-fragments.—These are chiefly thin flattish pieces, occasionally ribbed, suggesting derivation from *Pecten*, and irregular and more or less angular particles of the thicker parts of shells. *Inoceramus*-prisms are present, though not very numerous. The Norwich specimen contained many fragments derived apparently from a small *Terebratula*. Stout short lengths of echinoid spines and fragments of the test, ossicles of Starfish or of Crinoids were all not uncommon. Small spines of an Echinoderm were exceptionally numerous in the specimen from Norwich. Fragments of Bryozoa were frequent in the Isle of Wight specimen, and a few occurred in those from Salisbury and Norwich.

A few fragments of fish teeth, and here and there a coprolite, were noted in the Isle of Wight chalk, and one or two were seen in that from Salisbury.

Sponge-Spicules.—It is a curious fact that while sponge-spicules are abundant in the meal of flints in all the zones of the Upper Chalk none occur among the coarser particles when a sample of the chalk itself is washed. It is true that a few trifid spicules, and some that are apparently monactinellid forms, can now and then be recognised in thin sections, but above the zone of *M. cortestudinarium* they are never abundant, and the siliceous wall of the spicule is either entirely dissolved or replaced by calcite.

M. Cayeux[†] remarks that judging by the evidence of thin sections one would conclude spicules were nearly absent in the zone of *T. gracilis*, but by acting on the chalk with weak acid a residue is obtained which is rich in spicules. We have experimented in the case of one specimen of the *Actinocamax quadratus* zone with a weak solution of acetic acid, but without result, although a thin section showed small spicules were present. In the meal found in the centre of a single Paramoudra flint from the zone of *Bel. mucronata*, near Norwich, Dr. Hinde obtained no less than 160 different forms belonging to 32 genera and 38 species, the four chief families being represented. Dr. Hinde[‡] remarks, "So far as these comparisons extend the sponges of this Chalk flint may have inhabited a depth of 1,700 fathoms."

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[*] Kindly sent by Mr. Sothern at the request of Mr. H. B. Woodward.

[†] Contribution à l'étude Micrographique des Terrains Sédimentaires, p. 290.

[‡] Fossil sponge spicules from the Upper Chalk, Dr. G. J. Hinde, p. 75, Munich (1880).

Foraminifera.—Foraminifera are fairly abundant in this zone, and from the washings 53 species were isolated and named by Mr. F. Chapman. They include a new species of *Reophax*, and another of *Haplophragmium*.

Families.	Genus.	No. of Species.	——
Lituolidæ - -	Reophax - -	1	New species.
	Haplophragmium -	1	New species.
	Lituola - - -	1	
	Ammodiscus - -	1	
Textulariidæ -	Textularia - - -	3	
	Verneuilina - -	1	
	Tritaxia - - -	2	
	Spiroplecta - -	1	
	Gaudryina - -	3	
	Bulimina - - -	7	
	Bolivina - - -	2	
	Pleurostomella - -	1	
Lagenidæ - -	Nodosaria - - -	6	
	Frondicularia - -	2	
	Flabellina - - -	1	
	Marginulina - -	1	
	Cristellaria - -	7	
	Polymorphina - -	1	
	Ramulina - - -	1	
Globigerinidæ -	Globigerina - -	1	
	Pullenia - - -	1	
Rotaliidæ - -	Truncatulina - -	2	
	Anomalina - -	2	
	Pulvinulina - -	2	
	Rotalia - - -	2	

The most persistent and at the same time the commonest species in the washings are *Textularia turris*, *Bulimina obtusa* and *B. brevis*, *Cristellaria convergens*, *C. rotulata*, *Anomalina ammonoides*, *Pulvinulina micheliniana*, *Rotalia Soldani*, *var. nitida* and *R. exsculpta*; *Ammodiscus incertus* occurred in two of the acid residues. A list of the species is given on p. 349.

Ostracoda.—The following is a list of the species which were isolated from the Norwich specimen and named by Mr. F. Chapman:—

Paracypris siliqua, *J. & H.*
Cythereis ornatissima, *Reuss*
„ „ var. paupera, *J. & H.*
„ „ var. nuda, *J. & H.*
Cytheropteron umbonatum, *Will.*
„ alatum, *Bosquet*
„ concentricum, *Reuss*

Cytheridea perforata, *Roemer*
Cytherella ovata, *Roemer*
„ obovata, *J. & H.*
„ Muensteri, *Roemer*
„ williamsoniana, *Jones*
„ „ var. granulosa, *J. & H.*

Examination of the Residues.

The results of six analyses of the Chalk of this zone are shown on the annexed table, three of which are taken from Dr. Hume's "Chemical and Micro-Mineralogical Researches."

While the Dorchester specimen will compare in the amount of insoluble material with the zone below, those from Salisbury and the Isle of Wight show an increase of fine clay.

The comparatively large percentage of coarse residue in the Salisbury specimen is largely accounted for by the amount of iron oxide, but there is also a marked increase in the number of arenaceous Foraminifera. These, as in the Yorkshire specimen of the lower zone, were chiefly *Ammodiscus* and *Rhizammina*, the former also occurring in Dr. Hume's specimen from the Isle of Wight.

Detrital Minerals.—The only detrital minerals which occurred in this zone were quartz and felspar in small sub-angular and angular grains. They seem to vary in quantity, being most numerous in the specimens from Dorchester and Norwich. In the first mentioned sample a single large grain was cemented to a grain of glauconite of similar size; the remainder were small particles measuring from .1 mm. to ·03 mm. The Norwich specimen also contained one grain of considerable size. Dr. Hume records the complete absence of detrital minerals in his Isle of Wight specimen

Secondary Minerals.—With the exception of the one grain noted above, only a few minute spherules of glauconite occurred.

Cylindrical lengths of iron oxide—red brown exteriorly, darker inside, were found in the residue of the Salisbury specimen, while more than half the coarse residue in the specimen from Norwich consisted of small masses of porous iron oxide. With the exception of one small piece this material was absent in the specimen from Dorchester. Dr. Hume notes Limonite in the chalk of this zone from the Isle of Wight.

TABULATION OF RESULTS. ZONE OF BELEMNITELLA MUCRONATA.

Number.	Locality.	General Composition.						Composition of Coarse Residue.					Remarks.
		Amount of Material.	Per cent. Soluble in Acid.	Per cent. of Coarse Residue.	Per cent. of Fine Residue.	Total per cent. Residue.	Colour.	Detrital Minerals.	Maximum size of grains.	Average size of grains.	Secondary Minerals.	Foraminifera.	
		gram's							m m	m m			
114	Dorsetshire. Dorchester	85·807	99·374	·001	·625	·626	Grey	Quartz	·27	·08	Glauconite. Iron oxide	None	The coarse residue consisted of 30 or 40 mineral grains, the largest being cemented to a grain of glauconite of equal size, of bright pale green colour. About half a dozen minute spherules of glauconite also occurred-only one particle of iron oxide. (The coarser organic ingredients consist of cells, spheres, and a few larger Foraminifera; these, with a few shell-fragments, form about 15 per cent. of the rock.)
115	*Studland Bay	78·16	99·15	·013	·835	·848	—	Quartz	—	—	—	—	The coarse residue, chiefly ferruginous grains, minute and rounded, sometimes darker inside. A few colourless quartz grains.
116	*Studland Bay	82·58	99·41	·003	·584	·587	—	Quartz, felspar	·18	–	—	—	In the residue, grains of felspar were more numerous than those of quartz.
117	Wilts. Salisbury	86·537	98·978	·055	·967	1·022	Brownish grey	Quartz	·17	·07	Iron oxide	Rhizammina, Ammodiscus	Three-fourths of this coarse residue consisted of cylindrical lengths of iron oxide, and the remainder was chiefly the debris of arenaceous Foraminifera. Short lengths of the tubes of *Rhizammina* were abundant, and several specimens of *Ammodiscus* occurred. Few mineral grains; no glauconite. (Minute Foraminifera, with cells, spheres, and shell-fragments form about 12 per cent. of this specimen.)
118	*Isle of Wight. Culver Cliff	80·91	98·15	·004	1·85	1·854	Deep brown	None observed	—	—	Limonite	Ammodiscus	
119	Norfolk. Norwich	88·374	99·214	·009	·777	·786	Brownish grey	Quartz, felspar	·19	·08	Iron oxide	None	The greater part of this residue consisted of rather large pieces of iron oxide, but there was an appreciable quantity of sand. No arenaceous Foraminifera, spicules, or other matter occurred. (Foraminifera exceptionally abundant, mostly minute Textularians (? *T. globulosa*), with a few *Globigerinæ* and nautiloid forms. Shell-fragments rather scarce: the whole forming about 35 per cent. of the rock.)

* Chemical and Micro-Mineralogical Researches, page 68.

TRIMINGHAM CHALK. ZONE OF OSTREA LUNATA.

Microscopic Aspects.

This chalk, a firm earthy limestone, white in colour, but streaked in some places with grey veins, is rather mealy to the touch, its texture recalling to the mind that of the zones of *Holaster planus* and the base of *Micraster cortestudinarium*.

Thin sections show that calcareous particles, which appear to be chiefly derived from shells, are extremely abundant in it, and these, with Foraminifera, cells, and "spheres," form at least 50 per cent. of the rock. Viewed in the sections these shell-fragments are mostly small, but amongst them are to be seen long thin fibrous pieces, probably derived from *Ostrea lunata* and few, if any, suggest derivation from *Inoceramus*. Fragments of the plates, spines, and ossicles of various Echinoderms can be detected, and smallish pieces of Bryozoa are sometimes cut through. The Foraminifera are chiefly minute Textularians and isolated cells with a few *Globigerinæ*, larger indefinite forms, and here and there a large *Globigerina*; Spheres also are present. The even texture of the rock is, however, frequently broken by veins in which coarse organic particles, such as fragments of *Ostrea lunata*, plates, spines, or ossicles of Echinoderms, and the larger Foraminifera are gathered together. Minute green grains are scattered thinly through the rock, and under crossed Nicolls minute mineral grains can here and there be discerned.

Examination of Washings.

This chalk is easily broken up and the coarser particles are readily separated by levigation. Examination of the coarser part of the material shows that many of the shell-fragments are thin wafery pieces obviously derived from *Ostrea lunata*, others less numerous, flat or ribbed, are probably derived from *Pecten*, small fragments of *Terebratula* and also of *Rhynchonella* were also observed. *Inoceramus*-prisms are present, but are not numerous. Echinoid spines and plates were also noted, but ossicles of *Asteroidea* are not common. Fragments of Bryozoa are fairly numerous. No sponge-spicules were seen. Foraminifera are abundant, and among those isolated from the washings the following species were named by Mr. Chapman :—

Lituola ovata, *Marsson*
Textularia sagittula, *Defrance*
Bulimina elegans, *Brady*
„ „ var. exilis, *Brady*
„ rimosa, *Marsson*
„ Presli, *Reuss*
„ pupoides, *d'Orb.*
Bolivina sp. (near punctata, *d'Orb.*)

Lagena globosa, *Montf.*
Nodosaria consobrina, *d'Orb.*
„ raphanistrum, *L.*
„ Zippei, *Reuss*
„ obliqua, *L.*
„ pauperata, *d'Orb.*
„ farcimen, *Reuss*
Flabellina cordata, *Reuss*

Marginulina glabra, *d'Orb.*
Vaginulina legumen, *L.*
Cristellaria rotulata, *Lam.*
„ gaultina, *Berth.*
„ planiuscula, *Reuss*
„ gibba, *d'Orb.*
Polymorphina gibba, *d'Orb.*
„ communis, *d'Orb.*
„ sp.
Ramulina aculeata, *Wright*
Globigerina bulloides, *d'Orb.*
Pullenia sphæroides, *d'Orb.*
Pullenia quinqueloba, *Reuss*
Discorbina globularis, *d'Orb.*
Truncatulina ungeriana, *d'Orb.*
„ lobatula, *W. & J.*
„ (*Marsson's* figure).
„ sp.
Anomalina ammonoides, *Reuss*
„ sp.
Pulvinulina elegans, *d'Orb.*
Rotalia Soldani, *d'Orb.*
„ sp. (not typical Soldani).
„ exsculpta, *Reuss*

In the two washings made from this chalk the most abundant forms were *Bulimina pupoides*, a *Bolivina* near *punctata* (d'Orb), *Truncatulina lobatula* and *Rotalia Soldani*. *Pulvinulina micheliniana* and *Rotalia exsculpta* are comparatively rare. It is remarkable that a deposit containing so much sand should be absolutely free from arenaceous Foraminifera. The only form observed in the acid residue was a minute silicified Textularian.

Examination of the Residue.

The percentage of insoluble material in the specimen from Trimingham, though considerable, is not larger than that of some other specimens of the Upper Chalk, and though it is exceeded by two examples from the zone *M. cortestudinarium*, and by the highest Yorkshire chalks, nevertheless it is among the highest of this division. It differs from all others most markedly in the character of the coarser residue. This nearly equals in amount the coarse residues obtained from the Chalk Rock of Medmenham, but instead of glauconite more than one half of it is fine sand, in even sized particles; one-fourth consists of porous iron oxide in rather large, irregular fragments, and a fifth was glauconite and green-grey mud. Amongst the mineral grains Mr. Teall recognises quartz, mica, an alkali felspar, microcline, rutile, tourmaline, and zircon. None of the grains exceed ·10 mm., the average being ·05 mm. The grains of glauconite are all small and match the grains of quartz in size.

The sample from Mundesley was sent me by Mr. C. Reid and was obtained from the well mentioned on p. 263. It proved to be a slightly purer chalk than that obtained from Trimingham. The amount of the coarse residue was a little larger. The quantity of fine sand was nearly the same, but the iron-oxide was almost entirely replaced by minute bright spherules of Marcasite. No arenaceous Foraminifera were found.

ZONE OF OSTREA LUNATA.

Number.	Locality.	General Composition.						Composition of Coarse Residue.									Remarks.
		Amount of Material.	Per cent. Soluble in Acid.	Per cent. of Coarse Residue.	Per cent. of Fine Residue.	Total per cent. Residue.	Colour.	Detrital Minerals.	Estimated per cent.	Maximum size of Grains.	Average size of Grains.	Secondary Minerals.	Estimated per cent.	Average size of Grains.	Organisms.	Per cent.	
120	Trimingham	gram's 86·857	97·186	·458	2·356	2·814	Brownish grey	Quartz, mica, alkali felspar, microcline, rutile, tourmaline, zircon	52	m m 09	m m ·05	Iron oxide, Glauconite and green matter	25 19	— ·06	None Indeterminable matter	— 2	With the exception of one minute silicified Textularian no Foraminifera were detected. The glauconite was in minute grains from dark olive green to a pale grey green in colour. A few casts of foraminiferal cells occurred, and one or two small rods. Mica abundant. (Shell-fragments are fairly common.)
121	Mundesley	79·949	97·854	·560	1·586	2·146	Grey -	Quartz, Mica-	68	·5	—	Marcasite Glauconite	28 3	— —	None Indeterminable -	1	Only one quartz grain of maximum size, the remainder being identical in size with those of Trimingham. The Marcasite was in minute bright globules. Mica-flakes abundant. A few rod-like lengths of Glauconite, and a rather large siliceous trifid spicule.

THE FINEST MATERIAL OF THE UPPER CHALK.

As a whole the amorphous material of the Upper Chalk appears to be made up almost entirely of the débris of calcareous organisms, and if we except the zones of *Holaster planus* and *Micraster cortestudinarium* there is a general absence of the larger definite calcite crystals which appear to be due to secondary crystallization, and to which attention has been drawn in the description of the Lower and Middle Chalk. The material which remains suspended in water after 20 seconds has elapsed, in washing almost any specimen of the Upper Chalk, if mounted in balsam or in glycerine and examined with an objective of one-eighth or one-tenth of an inch in focus, will be seen to consist of :—(1) Minute, irregularly-shaped crystals; (2) flat particles, evidently organic; (3) minute Foraminifera; (4) crystalloids, etc.; and (5) extremely minute particles.

The greater part of the first generally show a fibrous structure, and are presumably derived from shells; such particles are especially numerous in the mealy chalk of the zones of *H. planus* and *M. cortestudinarium*, but they may be accompanied and mixed with crystals, due to secondary crystallization, from which they can hardly be distinguished. Such particles also occur in higher zones, and seem to be proportionally abundant to the recognisable shell-fragments which can be seen in the rock. Many of the second are probably derived from Foraminifera, but it is not possible to speak with certainty in the case of a large number of particles. Though the secondary formation of calcite crystals is not so evident in the Upper Chalk as in the Lower and Middle, a redeposition of calcite has taken place on small particles as well as large, frequently masking their structure.

In the zone of *Micraster cortestudinarium*, where fragments of Bryozoa were common, an attempt was made to trace particles to this source; many also of the commoner Foraminifera were lightly crushed, and the particles compared with those in the Chalk, but in the majority of cases no definite conclusion could be arrived at. With the Foraminifera especially this is a different result to a similar experiment in the Lower Chalk. It may be noted, however, that there were several kinds of particles having a general resemblance to each other which frequently recurred, and it is possible that with a little more time for investigation their derivation may eventually be determined.

Crystalloids are extremely numerous, especially in all parts of the Chalk above the zone of *M. cortestudinarium*, and a large number of the minutest particles are clearly fragments of these bodies. No true coccoliths were observed, all the forms being merely thin concave discs. Rhabdoliths are rarer than in the lower beds of the Chalk. A few stellate forms of crystalloids were observed, but nearly all were masked by the accretion of calcite, Gully,* and their condition is almost identical with the stellate forms found in a sample of Barbados earth from Plumtree.

Though we have dealt in detail with the larger particles of the amorphous matrix, probably half of it consists of minute ătoms far too small for their derivation to be determined.

GENERAL SUMMARY.

From the tables of analyses it will be seen that the chalk of the zone of *Holaster planus* contains the largest amount of insoluble matter where it has the aspect of Chalk Rock, and less where it is merely a nodular chalk; thus the purest example coming from Pinhay, near Lyme Regis, with a residue of only ·686 per cent. of insoluble material, while those from Blandford, and Dover contain but little more insoluble matter. There is, however, a larger amount in a specimen from the Isle of Wight viz., 1·209 per cent.

But along the northern escarpment of the Chalk, with the advent of the Chalk Rock, the total amount of the insoluble residue is much greater; and though this amount decreases again northwards, yet in reality the decrease is in the amount of clay and not in that of the quartz or glauconite. Thus the highest percentage of insoluble material is found in the sample of Chalk Rock from Great Barford in Wiltshire, 2·90 per cent., decreasing to 1·75 per cent. at Medmenham in Bucks, to 1·52 per cent. at Luton, and to ·881 per cent. at Hitchin. But if we consider the relative quantities of the chief ingredients they can be tabulated as follows:—

Localities.	Clay.	Quartz.	Glauconite	Green Matter.
Barford - - - -	2·71	·03	·11	·05
Medmenham - - -	1·17	·01	·40	·08
Luton - - - -	·93	—	—	—
Hitchin - - - -	·58	·047	·14	·10

Passing from the area in which true Chalk Rock occurs and progressing to the north-east, the chalk of the zone of *H. planus* shows an increase in the percentage of insoluble argillaceous matter, which, slight though it be, is not without significance when viewed in the light of analyses of chalk from higher zones.

Sections of the Chalk Rock show that there must have been marked differences in the conditions under which this bed was laid down when compared with other beds of ordinary chalk. This rock consists of the débris of a variety of calcareous and siliceous organisms, embedded in a fine calcareous paste, now in the condition of finely granular calcite, and it would seem there was at this horizon a floor or series of floors at the bottom of the Cretaceous sea teeming with a life which indicates shallower water. The increase in the amount of fine clay with a little sand, together with the sharply-marked summit of these floors, suggests current action, which, in conjunction with decaying animal matter, has its sequel in the formation of glauconite and of nodules of slightly phosphatic chalk.

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*Quart. Journ. Geol. Soc., Vol. xlviii. p. 217 (1892)

In the zone of *Micraster cortestudinarium* the analyses are somewhat irregular, and for the first time one fails to see any definite sequence in the results. In two cases (Swanage and Medmenham) the percentage of the insoluble ingredients exceeds that of the zone below, and another from Blandford nearly equals in the amount of insoluble matter a specimen of the Chalk Rock from Barford, in Wiltshire. The smallest percentages come from examples from the southern and south-eastern counties, while that from Yorkshire, though not high in the amount of insoluble matter, is not lowest in the series.

The amount of coarse particles separated from the clay of the residues in specimens from this zone is extremely small. Mineral grains are most in evidence at the two extremes—Blandford (Dorset) and Enthorpe (Yorkshire). In the residue of the example from the latter locality were many arenaceous foraminifera. Layers of hard chalk, very similar in external appearance to the Chalk Rock, occur in the zone. But these beds do not exhibit the striking features of Chalk Rock when seen in thin sections, and they do not appear to have been laid down under similar conditions. A feature in many of them is the abundance of sponge spicules, the siliceous walls of which have in all cases disappeared and are replaced by calcite. It seems possible that the hardening of the chalk of these beds may be due to the dissolving of the silica of the spicules, giving room and opportunity for the subsequent re-crystallisaton of the calcite.

Compared with the zones below, the results of the analysis of samples taken from the zone of *Micraster coranguinum* are more even, and a first glance suggests a generally higher percentage of insoluble matter; but this is not so, the average of all the analyses of the zone of *M. cortestudinarium* giving 1·81 per cent., while that of the zone of *M. coranguinum* is 1·49 per cent. No sequence is observable in the results, and there is no special feature which attracts attention. The average of the analyses of all examples of the chalk of the zone of *Marsupites* from the southern and south-eastern counties shows a continued decrease in the insoluble residue, which is now only 1·04 per cent. A remarkable feature is, however, the sudden rise in the chalk of Yorkshire to 3·12 per cent. As might be expected, this is accompanied by a larger percentage of coarse residue, and by the occurrence of arenaceous Foraminifera, the tests of which form a considerable part of it.

In the succeeding zone of *Actinocamax quadratus* this feature is still more marked, Yorkshire examples from near Bridlington giving a residue of 3·281 per cent., though the average result from southern examples of the zone amounts to only ·682 per cent. of insoluble matter. Continuing the examination with the zone of *Belemnitella mucronata,* we find the average results of the analyses give a slight increase in the insoluble material, from ·682 per cent. to ·975 per cent. Finally, in tbe zone of *Ostrea lunata* it increases to 2·48 per cent.

The question arises, does this slight general increase above the zone of *M. coranguinum* indicate a general movement of re-elevation and a gradual return to shallower water? This certainly seems suggested by the final analysis of Trimingham and Mundesley Chalk, the residue of which reaches 2·48 per cent., and the coarse residue of which contains a quantity of fine sand containing many mica flakes.

In all the zones above the Chalk-Rock up to and including that of *Bel. mucronata,* the amount of coarse residue separated from the clay is exceedingly small, and though mineral grains occur in every sample, they are so few in number that they may be frequently counted. The greater part almost always consists of iron oxide; sometimes this may be oxidised marcasite, but it is frequently a porous material, very easily crushed.

The detrital minerals recognised in the Upper Chalk are very similar in character to those of the lower divisions. Mr. Teall is of opinion that if a sufficient quantity of material was examined the whole of the minerals found in the Lower Chalk would occur in the Upper.

From the foregoing summary of the analyses it will be seen that inorganic matter forms a very small part of the Upper Chalk, and the rock as a whole consists largely of calcareous materials. In the two lowest zones, those of *H. planus* and *M. cortestudinarium,* the rock contains a larger proportion of coarse particles than those which succeed them, and we may infer that much of the calcareous mud was derived from the disintegration of the forms whose traces still remain.

Besides the fragments of organisms still visibly present there were probably many others whose calcareous envelope was built up of the less stable form of calcium carbonate, viz., arragonite, and the decay of such must have added to the proportion of fine mud. Thus the zone of *M. cortestudinarium* is specially marked in the southern counties by the presence of numerous fragments of Bryozoa, yet we have been unable to recognise in the amorphous matrix any particles which could be definitely traced as originating from their decay. M. Cayeux* remarks on the part played by Bryozoa in the formation of the Chalk. He considers the arragonite, which enters largely into their composition, probably accounts for the breaking up of these organisms into unrecognisable atoms.

In the Chalk Rock also there were many Gasteropods, the shell of which has entirely disappeared, leaving only an internal cast, but in higher zones we do not find even casts (except of *Pleurotomaria*) till we reach the zone of *Ostrea lunata*.

The variety in the fragments of calcareous organisms in the Chalk Rock has already been alluded to; the chalk of the zone of *M. cortestudinarium* also contains a large proportion of particles of sufficient size to be recognised in thin sections as prisms of *Inoceramus*, fragments of Echinoderms, and pieces of Bryozoa. In the three succeeding zones recognisable calcareous particles are less numerous, and at least two-thirds of the chalk consists of the amorphous matter, which has been more particularly described in Volume II. p. 290.

Prisms of *Inoceramus* which, as far as the summit of the zone of *M. cortestudinarium*, were common amongst the coarse particles, become less numerous, and the shell-fragments which occur in the higher zones are chiefly thin flat pieces (sometimes with a slight concavity); most of these are plain, and may be derived from *Ostrea* or *Plicatula*, which are not uncommon fossils. Others which are often ribbed are probably derived from *Pecten*, and occasionally fragments of *Rhynchonella* or *Terebratula* can be recognised. Plates and ossicles of Echinoderms occur sparingly.

The chalk of the zone of *Bel. mucronata* contains, on the whole, a rather larger percentage of shelly fragments; they are practically the same as those in the zones below. This increase of shell-fragments is still more marked in the zone of *O. lunata*.

Although it is easy to separate a number of Foraminifera from any specimen of fairly soft chalk, thin sections show that fully grown tests, sufficiently perfect for recognition, form a comparatively small part of the deposit, and no chalk which we have seen will compare in the mere number of its Foraminifera with the specimens of true *Globigerina* ooze. Judging from thin sections of the Upper Chalk, minute Textularian and nautiloid forms are the most prominent, but by far the larger number, which in a thin section one refers to Foraminifera, are simple cells or spheres, and it is only in the two lowest zones of the Upper Chalk that these, with the fully-grown and more perfect forms, are an important ingredient of the chalk. In one specimen only are Foraminifera, other than cells or spheres, sufficiently abundant to merit special notice; this is the chalk of Norwich, of which they may be estimated to form about 35 per cent. of the rock.

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*Contribution à l'Etude Micrographique des Terrains Sedimentaires, p. 445.

The general facies of the foraminiferal fauna exhibits a certain amount of change even in the zone of *H. planus*. Forms which persistently occur in the Lower and Middle Chalk become rare, and some of them either do not occur at all or are only met with occasionally in the lower zones; while in the higher zones the change is still more marked.

Thus the *Globigerinæ*, though fairly numerous in the zone of *H. planus*, are scarce in all the higher zones, and it is only with difficulty that any specimen of this genus is found in washings, while such as come to hand are as a rule puny examples. M. Cayeux* remarks that *Globigerinæ* are quite a secondary and sometimes an almost negligable quantity in the formation of the Chalk.

The species peculiarly characteristic of the Upper Chalk is *Pulvinulina micheliniana*, and as far as our researches go, it is confined to the Upper Chalk, where it is one of the commonest species. Another abundant form is *Truncatulina ungeriana*; this species is recorded from several zones in the Lower and Middle Chalk, but is comparatively rare. A third form equally conspicuous is *Rotalia exsculpta*; it comes in at the upper part of the zone of *Micr. coranguinum*, and thenceforward is abundant. The ubiquitous *Anomalina ammonoides* is also an extremely common form through the whole of the Upper Chalk; *Rotalia Soldani* or its variety *nitida* occurs persistently in every specimen.

The individual specimens are frequently very fine and robust, though whenever one is seen in thin sections the shell seems weak and thin. Those which are so well preserved exteriorly are usually filled with the amorphous material of the Chalk in a semi-crystalline and hard condition, or with calcitic crystals, or the cell walls are strengthened by the deposition of calcite.

"Spheres" are most abundant in the zone of *Holaster planus*, and form at this horizon an important constituent of the Chalk; above this zone the number present in different samples varies, especially in the zone of *M.cortestudinarium*; still higher up they decrease, and though present in most examples of the Upper Chalk are never a conspicuous feature in thin sections.

The following list of Foraminifera has been compiled from those with which Mr. Chapman has supplied us, and from the lists in his published papers.

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*Contribution à l'Etude Micrographique des Terrains Sédimentaires, p. 455.

FORAMINIFERA FROM THE UPPER CHALK.

—	Zone of Holaster planus. 1	Phosphatic Chalk, Lewes. 2	Zone of M. cortestudinarium. 3	Zone of M. coranguinum. 4	Zone of Marsupites. 5	Zone of Actinocamax quadratus. 6	Phosphatic Chalk, Taplow. 7	Zone of Bel. mucronata. 8	Trimingham. 9
Nubecularia jonesiana, *Chapm.*	–	–	–	–	–	–	7	–	–
,, novorossica, *Karrer and Sinzow*	–	–	–	–	–	–	7	–	–
,, tibia, *Parker & Jones*	–	–	–	–	–	–	7	–	–
Spiroloculina limbata, *d'Orb.*	–	–	–	–	–	–	7	–	–
Miliolina agglutinans, *d'Orb.*	–	–	3	–	–	–	–	–	–
,, oblonga, *Montf.*	–	–	–	–	–	–	7	–	–
,, seminulum, *L.*	–	2	–	–	–	–	–	–	–
,, trigonula, *Lam.*	–	–	–	–	–	–	7	–	–
,, venusta, *Karrer*	–	–	–	–	–	–	7	–	–
Rhizammina indivisa, *Brady*	–	–	–	4	5	6	–	–	–
,, algæformis, *Brady*	–	–	–	–	–	6	–	–	–
,, sp.	–	–	3	–	–	6	–	–	–
Reophax sp. nov. (1)	–	–	–	4	5	–	–	–	–
,, sp. nov. (2)?	–	–	–	–	–	–	–	8	–
Haplophragmium agglutinans, *d'Orb.*	–	–	3	–	–	–	–	–	–
,, glomeratum, *Brady*	–	–	–	–	5	–	–	–	–
,, irregulare, *Roemer*	–	2	–	4	–	–	–	–	–
,, ovatum, *Hag.*	–	2	–	–	–	–	–	–	–
,, sp. nov. (1)	–	–	–	–	–	–	–	8	–
,, sp. nov. (2)? minuta	–	–	–	–	5	–	–	–	–
Lituola ovata, *Marsson*	–	–	–	–	–	–	–	8	9
Ammodiscus charoides, *P. and J.*	1	–	–	–	–	–	–	–	–
,, centrifuga, *Brady*	–	–	–	–	5	–	–	–	–
,, incertus, *Brady*	1	–	3	4	5	6	–	8	–
Textularia anceps, *Reuss.*	–	–	–	–	–	–	7	–	–
,, agglutinans, *d'Orb*	1	–	–	–	–	–	–	–	–
,, conica, *d'Orb.*	–	–	–	–	–	–	7	–	–
,, concava, *Karrer*	–	–	–	–	–	–	7	–	–
,, decurrens, *Chapm.*	–	–	–	–	–	–	7	–	–
,, globulosa, *Ehr.*	1	2	3	–	5	6	7	8	–
,, ,, var. striata, *Ehr.*	–	2	–	–	–	–	7	–	–
,, prælonga, *Reuss*	–	–	–	4	–	–	–	–	–
,, quadrilatera, *Schw.*	–	–	–	–	–	–	7	–	–
,, sagittula, *Defr.*	–	–	3	–	–	–	7	–	9
,, serrata, *Chapm.*	–	–	–	–	–	–	7	–	–
,, turris, *d'Orb.*	1	–	3	4	5	6	–	8	–
,, trochus, *d'Orb.*	–	2	3	4	–	–	7	8	–
Vernueuilina pygmea, *Egger.*	–	–	–	–	–	–	7	–	–
,, spinulosa, *Reuss*	–	–	3	4	5	–	7	–	–
,, triquetra, *Muenst.*	1	–	3	4	5	6	7	8	–
Tritaxia foveolata, *Marsson*	–	2	–	4	–	–	7	8	–
,, minuta, *Marsson*	1	–	–	4	–	–	–	–	–
,, pyramidata, *Reuss*	1	2	–	–	–	–	–	–	–
,, tricarinata, *Reuss*	1	2	3	4	5	–	7	8	–
,, sp. nov.	–	–	–	–	–	6	–	–	–

FORAMINIFERA OF THE UPPER CHALK—*continued.*

—	Zone of Holaster planus. 1	Phosphatic Chalk, Lewes. 2	Zone of M. cortestudinarium. 3	Zone of M. coranguinum. 4	Zone of Marsupites. 5	Zone of Actinocamax quadratus. 6	Phosphatic Chalk, Taplow. 7	Zone of Bel. mucronata. 8	Trimingham. 9
Tritaxia sp.	–	–	3	–	–	–	–	–	–
Spiroplecta annectens, *P. and J.*	–	2	–	4	–	–	7	–	–
,, anceps, *Reuss*	–	–	–	–	–	–	–	8	–
,, biformis, *P. and J.*	–	–	3	4	–	–	7	–	–
Gaudryina crassa, *Marsson*	1	–	3	4	5	–	–	8	–
,, filiformis, *Berth.*	1	–	–	–	–	–	–	–	–
,, jonesiana, *Wright*	–	2	–	4	–	–	7	–	–
,, pupoides, *d'Orb.*	–	2	3	4	–	–	–	8	–
,, rugosa, *d'Orb.*	–	2	3	4	5	–	7	8	–
Bulimina affinis, *d'Orb.*	–	2	3	4	5	6	7	–	–
,, brevis, *d'Orb.*	1	–	3	4	5	6	7	8	–
,, elegans, *Brady*	–	–	–	4	–	–	7	–	9
,, ,, var. exilis, *Brady*	–	–	–	–	–	–	–	–	9
,, murchisoniana, *d'Orb.*	–	2	3	4	5	–	7	8	–
,, ,, new var.	–	–	–	–	–	–	–	8	–
,, obtusa, *d'Orb.*	1	2	3	4	5	6	7	8	–
,, ovata, *d'Orb.*	–	–	–	–	–	–	7	–	–
,, obliqua, *d'Orb.*	–	–	–	4	–	–	7	–	–
,, orbigniana, *Reuss*	–	–	–	–	–	6	–	8	–
,, Orbignyi, *Reuss*	–	–	–	4	–	–	–	8	–
,, pupoides, *d'Orb.*	1	2	–	4	–	–	–	–	9
,, Presli, *Reuss*	–	–	–	4	5	6	–	–	9
,, polystropha, *Reuss*	–	2	–	–	–	–	–	–	–
,, rimosa, *Marsson*	–	–	3	–	–	–	–	–	9
,, subsphærica, *Reuss*	–	–	–	4	–	–	7	–	–
,, trigona, *Chapm.*	–	–	–	–	–	–	7	–	–
,, variabilis, *d'Orb.*	–	–	–	4	5	6	7	8	–
,, sp. nov.	–	–	–	–	–	6	–	–	–
Virgulina schreibersiana, *Czjzer.*	–	–	–	4	–	–	7	–	–
,, subsquamosa, *Egger*	–	–	–	–	–	–	7	–	–
Bolivina dilatata, *Reuss*	–	–	–	–	–	–	7	–	–
,, decorata, *Jones*	–	–	–	–	–	6	–	8	–
,, sp. nov. (near decorata)	–	–	–	–	–	6	–	–	–
,, nobilis, *Hantken*	–	–	–	–	–	–	7	–	–
,, obsoleta, *Eley*	–	–	–	4	–	–	–	8	–
,, punctata, *d'Orb.*	–	–	–	–	–	–	7	–	–
,, sp. nov. (near punctata)	–	–		–	–	–	–	–	9
,, strigillata, *Chapm.*	–	–	–	–	–	–	7	–	–
,, textilarioides, *Reuss*	–	–	–	–	–	–	7	–	–
Pleurostomella alternans, *Schw.*	1	–	–	–	5	6	–	8	–
,, subnodosa, *Reuss*	–	–	–	–	–	–	7	–	–
Lagena acuticosta, *Reuss*	–	–	–	–	–	6	-		–
,, globosa, *Montf.*	–	–	–	–	–	–	7	–	9
,, gracilis, *Will.*	–	–	–	4	–	–	–	–	–
,, striato-punctata, *P. and J.*	–	–	–	–	–	–	7	–	–

FORAMINIFERA OF THE UPPER CHALK—*continued.*

—	Zone of Holaster planus. 1	Phosphatic Chalk, Lewes. 2	Zone of M. cortestudinarium. 3	Zone of M. coranguinum 4	Zone of Marsupites. 5	Zone of Actinocamax quadratus. 6	Phosphatic Chalk, Taplow. 7	Zone of Bel. mucronata. 8	Trimingham. 9
Lagena sulcata, *Walker and Jacob*	–	–	–	4	–	–	7	–	–
,, striata, *Walker and Boys*	–	–	3	–	–	–	–	–	–
Nodosaria aculeata, *d'Orb.*	–	–	–	4	–	–	7	–	–
,, (D.) communis *d'Orb.*	1	2	–	–	–	–	7	–	–
,, consobrina, *d'Orb.*	1	2	–	4	5	–	7	8	9
,, filiformis, *d'Orb.*	–	–	–	–	5	–	–	–	–
,, farcimen, *Reuss*	–	–	–	4	5	–	–	8	9
,, hispida, *d'Orb.*	–	–	–	–	–	–	7	–	–
,, (D.) nodosa, *d'Orb.*	–	–	–	–	–	–	7	–	–
,, obscura, *Reuss*	–	–	–	–	–	–	7	–	–
,, obliqua, *Linn.*	–	–	–	4	–	–	–	–	9
,, oligostegia, *Reuss*	–	–	–	4	–	–	–	–	–
,, (D.) pauperata, *d'Orb.*	–	–	–	–	–	–	7	–	9
,, paupercula, *Reuss*	?	–	–	–	–	–	–	–	–
,, perpusilla, *Chap.*	–	–	–	–	–	–	–	8	–
,, polytrema ? *d'Orb.*	–	–	–	–	5	–	–	–	–
,, radicula, *Linn.*	–	–	–	–	–	–	7	8	–
,, raphanus, *Linn.*	–	–	–	–	–	–	–	8	–
,, raphanistrum, *Linn.*	–	–	–	–	–	–	–	–	9
,, (D.) Rœmeri, *Neug.*	–	–	–	–	–	–	7	–	–
,, tenuicosta, *Reuss*	–	–	–	–	–	–	7	–	–
,, Zippei, *Reuss*	–	–	–	4	–	–	–	8	9
Lingulina carinata, *d'Orb.*	–	–	–	–	–	–	7	–	–
Frondicularia archiaciana, *d'Orb.*	1	–	–	–	–	–	7	8	–
,, angulosa, *d'Orb.*	–	–	–	–	–	–	7	–	–
,, angusta, *Nilsson*	–	–	–	–	–	–	7	–	–
,, angustissima, *Reuss*	–	–	–	4	–	–	–	–	–
,, affinis, *Marsson*	–	–	–	–	–	–	–	8	–
,, solea, *Marsson*	–	–	–	4	–	–	–	–	–
,, verneuiliana, *d'Orb.*	1	–	–	–	–	–	–	–	–
,, sp.	–	–	–	–	–	–	–	8	–
Rhabdogonium tricarinatum, *d'Orb.*	1	–	–	4	5	–	–	–	–
,, ,, var. acutangulum, *Reuss*	1	–	–	–	–	–	–	–	–
Marginulina æquivoca, *Reuss*	1	–	–	–	–	–	–	–	–
,, debilis, *Berth.*	–	–	–	–	5	–	–	–	–
Marginulina elongata, *d'Orb.*	–	–	–	–	–	–	7	–	–
,, glabra, *d'Orb.*	–	–	–	–	–	–	7	–	9
,, trilobata, *d'Orb.*	–	–	–	–	–	–	–	8	–
Vaginulina legumen, *Linn.*	–	–	–	4	–	–	–	–	9
,, recta, *Reuss*	–	2	–	–	–	–	–	–	–
Cristellaria acutauricularis, *F. & M.*	–	2	–	–	–	–	–	–	–
,, Bronni, *Roemer*	–	–	–	–	–	–	–	8	–
,, cultrata, *Montf.*	1	2	3	4	–	–	7	8	–
,, crepidula, *F. & M.*	1	–	–	4	–	–	–	–	–
,, convergens, *Born.*	–	–	3	4	–	6	7	8	–

FORAMINIFERA OF THE UPPER CHALK—*continued.*

—	Zone of Holaster planus. 1	Phosphatic Chalk, Lewis. 2	Zone of M. cortestudinarium. 3	Zone of M. coranguinum. 4	Zone of Marsupites. 5	Zone of Actinocamax quadratus. 6	Phosphatic Chalk, Taplow. 7	Zone of Bel. mucronata. 8	Trimingham. 9
Cristellaria cymboides, *d'Orb.*	–	–	–	–	–	–	–	8	–
" gaultina, *Berth.*	1	2	–	4	5	–	–	–	?
" gaudryana, *d'Orb.*	–	–	–	4	–	–	7	8	–
" gemmata, *Brady*	–	–	–	–	–	–	7	–	–
" gibba, *d'Orb.*	1	2	–	4	–	6	–	–	9
" navicula, *d'Orb.*	–	2	3	4	–	–	7	8	–
" planiuscula, *Reuss*	–	–	–	4	–	–	–	–	9
" rotulata, *Lam.*	1	2	3	4	5	6	7	8	9
" triangularis, *d'Orb.*	–	–	3	4	–	6	7	–	–
" tricarinella, *Reuss*	–	–	3	–	–	–	–	–	–
" sp. nov.	1	–	–	–	–	–	–	–	–
Flabellina baudouiniana, *d'Orb.*	–	–	–	4	–	–	7	–	–
" cordata, *Reuss*	1	–	–	–	–	–	–	–	–
" ornata, *Reuss*	–	–	–	–	–	–	7	–	–
" pulchra, *d'Orb.*	–	–	–	4	–	–	–	–	–
" rugosa, *d'Orb.*	–	–	–	4	5	–	7	8	–
Polymorphina acuminata, *d'Orb.*	–	–	–	–	–	6	7	–	–
" communis, *d'Orb.*	–	–	–	–	–	–	–	–	9
" fusiformis, *Roemer*	1	2	–	–	–	–	–	–	–
" gibba, *d'Orb.*	–	–	–	–	–	–	7	–	9
" lactea, *W. & J.*	–	–	–	–	–	–	–	8	–
" rotundata, *Born.*	–	–	–	4	–	–	–	–	–
" sororia, *Reuss*	–	–	–	–	–	–	7	–	–
Uvigerina canariensis, *d'Orb.*	–	–	–	–	–	–	7	–	–
Ramulina aculeata, *d'Orb.*	–	2	3	4	–	–	7	8	9
" globulifera, *Brady*	–	–	–	4	–	–	–	–	–
" lævis, *Jones*	–	2	–	–	–	–	–	–	–
Globigerina æquilateralis, *Brady*	1	–	–	–	–	–	7	–	–
" bulloides, *d'Orb.*	1	2	–	4	–	–	7	–	9
" cretacea, *d'Orb.*	–	2	3	4	–	–	7	–	–
" linnæana, *d'Orb.*	1	–	–	–	5	–	–	–	–
" marginata, *Reuss*	1	2	3	4	5	–	7	8	–
Discorbina globularis, *d'Orb.*	–	–	–	–	–	–	–	–	9
" Bertheloti, *d'Orb.*	1	–	–	–	–	–	–	–	–
" sp.	–	–	–	4	–	–	–	–	–
Planorbulina clementiana, *d'Orb.*	–	–	–	–	–	–	7	–	–
" lorneiana, *d'Orb.*	–	–	–	–	–	–	7	–	–
Pullenia sphæroides, *d'Orb.*	–	–	–	–	–	–	–	–	9
" quinqueloba, *Reuss*	–	–	–	–	–	–	–	8	9
Truncatulina culter, *P. & J.*	1	–	–	–	–	–	–	–	–
" lobatula, *W. & J.*	1	–	–	4	5	–	7	8	9
" " (Marsson's type)	–	–	–	–	–	–	–	–	9
" refulgens, *Montf.*	–	–	–	–	5	–	–	–	–
" ungeriana, *d'Orb.*	1	–	3	4	5	6	–	8	9
" variabilis, *d'Orb.*	–	–	–	4	–	–	7	–	–
Anomalina ammonoides, *Reuss*	1	2	3	4	5	6	7	8	9

FORAMINIFERA OF THE UPPER CHALK—*continued.*

—	Zone of Holaster planus. 1	Phosphatic Chalk, Lewes. 2	Zone of M. cortestudinarium. 3	Zone of M. coranguinum. 4	Zone of Marsupites. 5	Zone of Actinocamax quadratus. 6	Phosphatic Chalk, Taplow. 7	Zon of Bel. mucronata. 8	Trimingham. 9
Anomalina ariminensis, *d'Orb.*	–	–	–	–	–	–	7	–	–
„ complanata, *Reuss*	–	–	–	–	–	–	–	8	–
„ grosserugosa, *Gümbel*	–	–	–	–	–	–	7	–	–
„ lorneiana, *d'Orb.*	–	–	–	4	–	–	–	–	–
„ rotula, *d'Orb.*	1	–	–	4	–	–	7	–	–
Pulvinulina elegans, *d'Orb.*	1	–	–	–	–	–	7	–	9
„ Haidingeri, *d'Orb.*	–	–	–	–	5	6	–	8	–
„ Karsteni, *Reuss*	–	–	–	–	–	–	7	–	–
„ micheliniana, *d'Orb.*	1	–	3	4	5	6	7	8	–
„ punctulata, *d'Orb.*	–	–	–	–	–	–	7	–	–
„ repanda, *Fichel & Moll.*	–	–	–	–	–	–	7	–	–
„ „ var. concamerata, *Mont.*	–	–	–	4	–	–	7	–	–
Rotalia Beccari, *Linn.*	–	–	–	–	–	–	7	–	–
„ Bosqueti ? *Reuss*	–	–	–	–	–	–	–	–	9
„ Soldani, *d'Orb.*	1	2	3	4	5	6	7	–	9
„ „ var. nitida, *Reuss*	1	–	3	4	–	6	–	8	–
„ exsculpta, *Reuss*	–	–	–	4	5	6	7	8	9
Gypsina cretæ, *Marsson*	–	2	–	–	–	–	–	–	–

CHAPTER XXIII.

CHEMICAL COMPOSITION OF THE UPPER CHALK.

A. The Chalk-Rock.

A sample of Chalk-Rock from near Aston Rowant in Oxfordshire was sent to Professor J. B. Harrison, the Government Chemist of British Guiana, who had kindly consented to make complete analyses of this and other samples of Chalk (see Vol. II. pp. 333 and 527). The result communicated by Professor Harrison was as follows:—

Organic matter, etc.		·40
Quartz		·10
Colloid silica		·48
Silicates and clay.	Combined silica	1·54
	Iron peroxide	·40
	Alumina	·89
	Manganese oxide	·27
	Magnesia	·52
	Potash	·23
Calcium sulphate		·31
Calcium carbonate		94·94
Magnesium carbonate		·25
		100·33

Traces of phosphoric acid and of soda were found.

Summarising the above results, they may be re-stated as follows in the column (A), a second analysis of a Chalk Rock without glauconite (B) from Redbourn Hill, near Urchfont (Wilts) being added for comparison. This was analysed at the same time but less completely.

	A	B
Calcium carbonate	94·94	98·35
Magnesium carbonate	·25	
Calcium sulphate	·31	
Silicates	3·85	·60
Colloid silica	·48	·05
Quartz	·10	·70
Organic matter	·40	·30
	100·33	100·00

An analysis of Chalk-Rock from Boxmoor, Hertfordshire, was made by Mr. P. G. Sanford, F.C.S., and published in the London Geological Field Class Report of Excursions during 1888 (1889, page 19). The specimen was dried at 100 deg. C., and gave :—

Insoluble residue, sand, silica, etc.	1·003
Soluble silica	·128
Lime	54·900
Magnesia	·374
Iron and Alumina ($Fe_2O_3+Al_2O_3$)	·347
Sulphuric acid	·465
Phosphoric acid	·713
Carbonic acid	42·101
	100·031

This analysis appears to have been carefully made, but Mr. Sanford gives the total amount of calcium carbonate as 97·001, with ·785 of magnesium carbonate; this, however, must be on the assumption that the phosphoric and sulphuric acids are not combined with lime. On the much more probable assumption that they are so combined, the following composition of the sample has been calculated by my friend Professor J. B. Harrison, F.G.S., F.C.S. :—

Insoluble residue	1·003
Soluble silica	·128
Calcium carbonate	94·750
Calcium sulphate	·732
Calcium phosphate	1·554
Calcium oxide	·732
Magnesium carbonate	·785
Peroxides of iron and alumina	·347
	100·031

Two analyses of the Chalk Rock of Cambridgeshire were made for the Geological Survey in 1880 by Dr. Frankland, F.R.S., and were published in the Memoir on the Geology of the Neighbourhood of Cambridge (1881). The samples were obtained from near Newmarket, the precise localities not being recorded in that memoir, but, if my recollection is correct, one of them came from Westley Waterless and the other from the pit at Stetchworth. The analyses are as follow :—

	A	B
Moisture at 100 deg. F.	·13	·20
Organic matter	·32	·31
Sexquioxide of iron	·64	·69
Alumina	·62	·64
Calcium carbonate	97·25	98·57
Magnesium carbonate	trace	—
Phosphoric anhydride	·21	·20
	99·17	100·61

How the amount of calcium carbonate in these analyses was calculated we do not know, but there can be little doubt that a small quantity of the lime was combined with the phosphoric anhydride in the form of phosphate of lime.

B. The White Chalks.

Many analyses have been made of the Upper Chalk, including samples from many different horizons and localities; they show it to be a remarkably pure calcareous deposit varying very little in composition, and almost always containing from 97½ to 99 per cent. of calcium carbonate. The amount of insoluble siliceous matter is seldom over 1 per cent., and the amount of soluble silica is always very small, both in the zones which contain many flints and in those which contain but few flints. There is, in fact, no inverse relation between the abundance of flints and the quantity of silica disseminated through the chalk.* This point is well brought out by two analyses which Professor J. B. Harrison was good enough to have made for me in the laboratory at Georgetown, British Guiana, by the method he has devised for separating the different siliceous ingredients of such rocks.† The results were as below, No. 1 being a sample of chalk with many flints from Great Durnford, north of Salisbury, and No. 2 being from the chalk of Bishops Down, Salisbury (*Marsupites* zone with few flints):—

	1	2
Moisture	·30	·20
Quartz	·32	·50
Clay	1·18	·45
Colloid silica	·50	none
Carbonates of lime and magnesia	97·70	98·85
	100·00	100·00

So far as these two analyses go, it would appear that the chalk which has most flints has also most disseminated silica, both soluble and insoluble.

Prof. Ch. Barrois has published three analyses of chalk samples from the zones of *Act. quadratus* and of *Bel. mucronata* in the south of England.‡ The analyses were made by M. Duvillier in the laboratory of the Faculté des Sciences at Lille, and are as follows :—

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* See Geol. Mag., Dec. III., Vol. x. p. 541 (1893).

† See Quart. Journ. Geol. Soc., Vol. xlviii. p. 182 (1982).

‡ Recerches sur le Terr. Crét. Sup., 1876, pp. 42 and 100,

	1	2	3
Clay	·70	·38	·42
Soluble silica	·10	·11	·10
Oxide of iron	·08	·54	·28
Phosphate of lime	·08	·18	·26
Carbonate of lime	98·85	97·99	98·17
Carbonate of magnesia	·15	·62	·74
	99·96	99·82	—

No. 1 is from a quarry in the zone of *Act. quadratus* near Otterbourn Hampshire.

No. 2 is from the zone of *Bel. mucronata* at Studland, Dorset.

No. 3 is from the indurated beds of the *Bel. mucronata* zone at Corfe Castle, Dorset.

Four analyses of chalk from the East Quarry on Ashey Down, in the Isle of Wight, are given in the Geological Survey Memoir on that island (Second Edition, page 255,. Three of these are quoted below.

No. 1 was made at Tennant's Works, Manchester, in 1874.

No. 2 was made by Dr. Voelcker in 1875.

No. 3 was made by Mr. Pattison, of Newcastle-on-Tyne.

	1	2	3
Carbonate of lime	98·53	98·04	98·01
Sulphate of lime	—	—	·06
Magnesia	—	·07	·94
Alumina and oxide of iron	·44	·21	·60
Silica	·17	1·28	·40
Moisture	·31	·39	·20
	99·45	100·00	100·21

Two careful analyses of Upper Chalk were made by Professor J. T. Way, and published in 1851;* the first is described as "Upper Soft White Chalk" from near Crondell Church (near Farnham), and the second as "Upper Chalk from a pit about half a mile north of the preceding." They are tabulated below, together with a third analysis made by Mr. Grant-Wilson, of the Geological Survey of Scotland, of a sample of chalk enclosed in one of the irregular flint-layers in the Upper Chalk of Ormsby, Lincolnshire (see page 272).

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* Journ. Roy. Agric. Soc., vol. xii., p. 545. etc.

	1	2	3
Water	—	—	·75
Sand and siliceous matter, insoluble in acids	1·46	·87	1·37
Carbonic acid	42·48	42·57	42·35
Sulphuric acid	none	·09	·05
Phosphoric acid	·04	·08	—
Lime	55·72	55·18	53·91
Magnesia	·06	·30	·18
Potash	·17	·22	—
Soda	·02	·21	—
Oxide of iron and Alumina	1·05	·40	·43
	100·00	99·92	99·04

If the amount of carbonate of lime in these chalks is calculated from the ascertained amounts of carbonic acid in each they have only between 96 and 97 per cent., and the first one seems to have a slight excess of lime, possibly present as a silicate.

The following are analyses of three pure white chalks:—

No. 1. Being a sample from Shoreham, Sussex; probably zone of *Actinocamax quadratus*, analysed by Professor D. Forbes (see Quart. Journ. Geol. Soc., Vol. xxvii. p. 49).

No. 2. A sample from Driffield, Yorkshire (*Marsupites* zone), analysed by Mr. Th. Hodgson, of Bradford (see Quart. Journ. Geol. Soc., Vol. xxxi. p. 112). I have recalculated this, as the original analysis shows 5·20 per cent. of moisture.

No. 3. A sample from the large quarry at Cliffe, in Kent (possibly in the zone of *Act. quadratus*). This analysis was published by Mr. Whitaker in Vol. iv. of the Geological Survey Memoirs, p. 15.

——	1	2	3
Carbonate of lime	98·40	98·41	98·52
Carbonate of Magnesia	·08	·16	·29
Sulphate of lime	—	—	·14
Oxide of iron and alumina	·42	·22	·40
Silica	1·10	1·21	·65
	100·00	100·00	100·00

The following is an analysis of one of the seams of grey marly clay which occur in the Upper Chalk of Driffield, in Yorkshire. This sample was taken from a well dug in Driffield in 1873; it was analysed by Mr. Thomas Hodgson, of Undercliffe, Bradford, and published in a paper by Mr. R. Mortimer (Quart. Journ. Geol. Soc., Vol. xxxi. p. 114). The first column gives the analysis as published, but as over 12 per cent. of moisture was left in the sample before analysis, I have recalculated the composition which the material would have if the moisture had been driven off; this is given in the second column.

Moisture	12·15	—
Organic matter and combined water	1·67	1·90
Carbonate of lime	33·40	38·02
Carbonate of magnesia	·50	·56
Oxide of iron	7·05	8·02
Alumina	10·23	11·63
Alkaline salts	·20	·22
Silica	34·80	39·60
	100·00	99·95

An analysis of the sandy bed in the chalk bluff at Trimingham, Norfolk (see p. 262), was made for me by my colleague, Mr. Grant-Wilson, in 1885, with the following result:—

Carbonic acid	42·04
Sulphuric acid	·36
Lime	51·99
Magnesia	·61
Alumina	·39
Protoxide of iron	·77
Residue insoluble in HCl.	2·86
	99·02

In this analysis the amount of lime and magnesia found is not quite sufficient to combine with the whole of the carbonic acid. The iron may be in the state of a sulphide.

Partial analyses of many samples of Upper Chalk have been made by Mr. W. Hill, and have been given in tabular form in Chap. XXII.

C. FLINTS.

A flint is not generally a concretion of similar aspect and composition throughout its mass. It is true that in some parts of the Chalk there are flints which consist of solid, translucent chalcedonic silica from the centre to the circumference, but as a rule there is an outer crust or rind of varying thickness, which is generally white and opaque, but is sometimes stained yellow or pink on the outside.

This white crust varies much in its degree of hardness; sometimes it is as dense and hard as the interior of the flint; sometimes it is comparatively soft and granular or loosely coherent, so that much of it can be broken away from the outside of the nodule; in other cases it is composed of two or three layers, one of which is often more chalcedonic than the others.

The white crust also varies much in thickness, from a mere thin rind or cortex about an eighth of an inch thick to a thick encrusting envelope from half to three-quarters of an inch thick, according to the size of the flinty nodule. Occasionally, moreover, nodules are found which consist almost entirely of such white material, with only a small nucleus of translucent flint in the centre.

The varying density of this white portion of a flint nodule appears to depend on the amount of silicification which it has undergone. In some of them there is a good deal of chalk, and I think this is generally the case with the softer varieties, but more experiments are needed to confirm this supposition. So far as I know, only one complete analysis of the outer crust of a flint has yet been made, and this was the crust of a flint from the Chalk of Lincolnshire, taken from a pit near Cadeby House, north of Louth. The analysis was made by Mr. M. Staniland,* and is as follows :—

Analysis of the Crust of a flint from Cadeby, Lincs.

Insoluble portion:		
Silica	45·12	
Alumina (by difference)	·76	
Peroxide of iron	·67	
Lime	trace	46·55
Soluble portion:		
Moisture	1·06	
Carbonic acid	22·65	
Lime	27·88	
Peroxide of iron	1·73	
Alumina and Magnesia	traces	53·32
		99·87

It should be mentioned, however, that Mr. Staniland, finding there were visible pieces of chalcedonic silica scattered through the material, sifted these out after gently crushing the whole, and his analysis is that of the residue after the separation of the greater part of the pure silica. Consequently, the real proportion of the silica to lime in the sample was not ascertained, but must have been very much greater than is shown by the analysis of the residue. In this residue it appears to be about 44 to 50, but in the bulk of the sample it is more likely to have been as 60 to 30.

All, therefore, that we can infer from this analysis is that there was a considerable amount of calcium carbonate (chalk) present in the flint-crust; but in the case of another flint-crust tested for me by Professor J. B. Harrison, only ·253 of lime was found, this sample consisting almost entirely of pure silica.

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* See Geology of East Lincolnshire, Mem. Geol. Survey, 1887, p. 40.

CHAPTER XXIV.

BATHYMETRICAL CONDITIONS DURING THE FORMATION OF UPPER CHALK.

In the British Isles there is small evidence on which to base any conception of the actual geography of the region during the formation of the Upper Chalk, and we shall not attempt any such restoration. There are, however, several lines of evidence which afford concurrent testimony for the conclusion that the period was ushered in by a movement of elevation, followed by a prolonged movement of subsidence; while in the highest beds there is some evidence of that final upheaval which brought the Cretaceous period to a close.

1. Elevation.

The chief facts presented by the Chalk-Rock beds which indicate a general upheaval of the British area were noticed by me in 1892.* They are the reappearance of Gasteropoda, the recurrence of glauconite grains in considerable quantity, and the existence of phosphatic nodules. Referring to these facts, I remarked, "This sudden recurrence of peculiarities which characterise the Chalk Marl and Totternhoe Stone, associated with a fauna of similar character, compels us to conclude that the sea had again become shallower by the rise of a part of its floor." In 1894 Dr. W. F. Hume reviewed the same facts and came to the same conclusion.†

Since these dates some further evidence of upheaval and its results has been obtained, and in marshalling the facts for the present statement of the case it will be convenient to group them under three heads—(1) the stratigraphical facts, (2) the lithological evidence, and (3) the zoological evidence.

Stratigraphical Evidence.—The principal evidence of this nature is found in Ireland and in France. In Ireland there is nothing which can properly be regarded as equivalent to the zone of *Holaster planus*. The base of the Upper Chalk in Antrim appears to consist of sandy glauconitic limestones, containing *Echinocorys scutatus*, *Spondylus spinosus*, *Terebratula carnea*, *Rhynchonella limbata*, and some other fossils; but these do not include *Holaster planus*.

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* Building of the British Isles, Second Edition, p. 264.

† Proc. Geol. Assoc., Vol. xiii. p. 234.

By Professor Barrois these sandy beds were regarded as a condensed equivalent of the zones of *Terebratulina gracilis* and *Holaster planus*, but the evidence for this is weak. Dr. Hume is doubtful whether any part of the Irish series represents the English zones of *Rhynch. Cuvieri* and *Terebratulina.*[*] He admits a break and unconformity in some places between the sandy limestones and the yellow (Cenomanian) sandstone below, but he discovered casts of a *Micraster*, which he identified as *M. breviporus* in the former, and he remarks upon the resemblance which some of the Irish fossils bear to those of the English Chalk Rock. This resemblance, however, seems to be more general than particular. *Micr. breviporus*, if correctly identified, is doubtless a low zonal species, but the other two mentioned (*Spondylus spinosus* and *Ostrea semiplana*) are just as abundant in the higher zones as in the lower. Professor Barrois recorded *Echinoconus subrotundus* from these beds, but Dr. Hume found only *Ech. conicus*, which is not common in England below the *M. coranguinum* zone. The same may be said of *Rhynchonella limbata.*

Having regard to the physical break and to the small thickness of the Chloritic Chalk which separates the sandy beds from the White Chalk of the *Marsupites* zone, I am inclined to take the view that not only the zone of *Holaster planus*, but also the whole or greater part of the *M. cortestudinarium* zone, is absent in Ireland. It seems to me very probable that the *Inoceramus* beds, with the *Rhynchonella* band at their base, correspond to the lower part of our *M. coranguinum* zone, the presence of species of *Catopygus* and *Pseudodiadema* being due to the shallowness of the water and the neighbourhood of land.[†]

Turning now to France, and glancing first at Touraine (see p. 299), we find there a complete succession through the Turonian and Lower Senonian, the component members of which M. de Grossouvre has recently been able to correlate with the normal succession in Normandy. It is evident from his description that the beds which there represent the zones of *Terebratulina. Holaster planus*, and *Micraster cortestudinarium* are all of a comparatively shallow water character, while the overlying zones show a gradual passage through glauconitic marls and nodular chalk into a siliceous chalk with many flints. Near Tours the lower beds consist of glauconitic marls and hard sandy limestones, containing many Bryozoa and Oysters, the highest of the hard beds exhibiting an irregular eroded surface, often covered with green matter. On this rests a white chalk, rather hard and rough, but forming such a contrast to the beds below that the line of contact can easily be followed in the slopes of the railway cuttings as the traveller passes by train between Chenonceaux and Blérela-Croix. This chalk is believed to belong either to the zone of *Marsupites* or to that of *Act. quadratus.*

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[*] Quart. Journ. Geol. Soc. Vol. liii. p. 595 and table opp. p. 568.

[†] *Catopygus elongatus*, Desor, occurs not unfrequently with *Micraster turonensis* in the middle part of the *craie de Villedieu* in Touraine, which is regarded by M. de Grossouvre as equivalent to the lower part of the *M. coranguinum* zone. See Bull. Soc. Geol. France, Serr. 3, Tom. xvii. p. 506 (1889.)

Again in the Cotentin, (Normandy) there is the remarkable outlier where a limestone containing *Belemnitella mucronata* rests upon sands which may be of Cenomanian or Lower Turonian age, with an entire absence of anything to represent the Upper Turonian or Lower Senonian.

In the north-east of France there is no such great break, but in the neighbourhood of Lille, Valenciennes, and Solesmes the zones of *Holaster planus* and *Micraster cortestudinarium* are reduced to a small thickness (see p. 291), the zone of *H. planus* near Lille being only represented by a glauconitic limestone which varies in thickness from 6 to 13 feet.

If at this epoch of the zone of *Hol. planus* subsidence was arrested and a reverse movement of elevation took place, some important physical changes must have been produced, and the set and strength of the marine currents must have been affected. It is not surprising, therefore, that the Chalk Rock should frequently exhibit appearances which seem to indicate the temporary arrestment of deposition with a certain amount of current action. Throughout the southern and central parts of England it repeatedly happens that the harder beds are hardest at the top, terminating in clearly-marked surfaces, and it is with these surfaces that the layers of green-coated nodules are generally associated, the nodules being either embedded in the indurated rock or resting upon its surface.

I agree with Dr. Hume in regarding these facts as the effects of a bottom current which was frequently strong enough to interrupt the deposition of chalky material, and this current must have carried the products of decomposing animal matter from some coastal region to the area where the rocky beds were being formed. The nodules are, however, only slightly phosphatic, so that the coast line was probably at a considerable distance.

Lithological Evidence.—This consists partly in the recurrence of the glauconitic grains, often in fairly large quantity, and partly in the larger size of the quartz-grains which occur in the chalk of the *Holaster planus* zone.

It is also a fact that the total average amount of insoluble residue, as well as the proportion of coarse residue, is greater in this zone than in that of *Terebratulina,* but this may possibly be explained on the assumption that the rate of accumulation was less in the one zone than in the other. It is obvious that if deposition of chalky material was slower, while the quantity of extraneous siliceous matter brought in a given time remained the same, a given bulk of chalk would contain a larger proportion of such siliceous matter. We shall not therefore lay stress on the greater total amounts of insoluble material, but rather on the larger size of the grains, and on the presence of glauconite.

Mr. Hill finds that the greater part of the insoluble residue obtained from the samples he examined consisted of glauconite grains, these sometimes forming 70 per cent. of such residue (see p. 315). In respect of size they are mostly small, but some range from ·3 to ·6 mm. in diameter. The occurrence of glauconite, often in sufficient quantity to give the rock a finely speckled appearance, is very suggestive of a recurrence to something like the bathymetrical conditions which prevailed in the time of the Lower Chalk, and these could hardly have been restored in any other way than by a general uplift of the region.

Although particles of detrital minerals are not abundant, quartz, felspar, and tourmaline have been observed, and though the quartz is usually in the condition of very fine sand, yet large grains occur in some places. The most notable instance is in the bed of quartziferous Chalk at Rew Farm, near Dorchester, where the grains range up to a size of 2 mm.; but in the Isle of Wight a single grain of ·72 was found.

It is noticeable that in the Isle of Wight a bed which exhibits the lithological characters of the Chalk Rock occurs near the top of the *Terebratulina* zone, showing that conditions favourable to the formation of such rock began to make themselves felt at that time. In a sample from this bed Dr. Hume found a coarse residue of ·048 per cent., "consisting almost entirely of glauconite grains and small particles of angular and rounded quartz." Augite, hornblende, and tourmaline were also observed.

Zoological evidence.—Writing in 1892, I remarked "that the Chalk Rock has every appearance of having been formed in much shallower water. Fossils are often abundant, Gasteropoda are not uncommon, and include such genera as *Turbo, Cerithium, Avellana, Aporrhais, Natica, Crepidula,* and *Emarginula,* the modern representatives of which do not live in deep water, some not ranging below 100 fathoms, and none lower than 150 fathoms."* This statement, however, requires some modification, for though most of the species belonging to these genera do live in less than 100 fathoms, yet if *Cerithiopsis* is read for *Cerithium* all have recent species which exist at depths of over 600 fathoms. When, however, the fauna of the Chalk Rock is contrasted with that of the *Terebratulina* zone and compared with that of the Totternhoe Stone or Chalk Marl, the contrast to the one and the resemblance to the other are very suggestive of a lessened depth of water.

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* Building of the British Isles, London, 1892, Second Edition, p. 264.

Dr. W. F. Hume, writing in 1895,[*] came to the same conclusion. He remarks on the recurrence of the genus *Holaster*, which disappears for a time in the Middle Chalk, only again becoming common in and just below the Chalk Rock. He also notices the return of Cephalopoda (*Ammonites*, *Scaphites*, *Heteroceras* and *Hamites*) as suggestive in this connection, and as recalling the abundance of these genera in the Lower Chalk.

Still later Mr. H. Woods discussed the Mollusca of the Chalk Rock,[†] and from his paper I quote the following passage: "That the fauna of the *reussianum* zone lived in water of less depth than the faunas of the other Turonian and Senonian zones will, I think, scarcely be disputed. The Chalk Rock is very thin generally, yet fossils are more numerous specifically and far more abundant generally than in the other zones. It is well known that at the present day we find a similar difference in passing from comparatively shallow water to greater depths; the number of species as well as the number of individuals living on the sea bottom diminishes considerably . . . . The relative richness of the fauna of the *reussianum* zone cannot be accounted for by any difference in the nature of the sea-bottom, since in its original soft state the chalk-ooze must have been, so far as animal life was concerned, uniform in character throughout the Chalk period. We can therefore only conclude that the change in the fauna was caused by a decrease in depth; and since the change is so marked the decrease was probably considerable."

He further remarks (*op cit.*, p. 400) that "in discussing the question of depth from the evidence supplied by the genera of Mollusca which have living representatives, we must consider three main points:—(1) The genera which have a limited bathymetrical range; (2) the depths at which the other genera are most numerous; (3) the relative abundance of the genera in the *reussianum* zone itself." He divides the genera into five groups, but the limit of range which he assigns to the first group is not correct, and some of the genera in his other groups are now known to have a greater range. I would also exclude the genera *Martesia* and *Turbo* (*sensu restricto*) from consideration. *Martesia* is a kind of Pholas, which bores in wood, and floating wood containing it might sink in any depth of water. *Turbo* as a fossil is indistinguishable from *Trochus* and *Calliostoma*. I think, therefore, the Chalk Rock genera may be arranged in three groups instead of in five, as follows:—

(1) Genera not now living below 300 fathoms. *Pleurotomaria*, a genus on the verge of extinction, and of which recent specimens have only been dredged from between 73 and 200 fathoms. *Cyprina*, which ranges to about 180 fathoms.

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[*] Natural Science, Vol. vii. p. 390.

[†] Quart. Journ. Geol. Soc., Vol. liii. p. 398 (1897).

Ostrea, ranging to 277 fathoms off Marseilles (Locard.) *Plicatula* and *Trapezium* the range of which I have been unable to ascertain exactly, but *Plicatula* is said not to range below 100 fathoms; both are certainly now shallow water forms, whatever they may have been in Cretaceous time.

(2) Genera which now range to over 400 fathoms, but are not found beyond 800. These are *Crepidula*, *Emarginula*, *Turbo* (if present), *Cardium*, *Cardita*, *Pecten*, and *Spondylus*. The first two range to over 450 fathoms on American coasts. *Cardita* goes to 500 fathoms and *Spondylus* to 640 in the Bay of Biscay.

(3) Genera which have representatives ranging to 1,000 fathoms or more:—*Aporrhais*, *Cerithiopsis*, *Dentalium*, *Natica*, *Trochus*, *Arca*, *Limopsis*, *Nucula*, *Nuculana*, *Lima*, *Modiola*, and *Cuspidaria*.

The genera which are most frequently met with as fossils in the Chalk Rock are *Aporrhais*, *Cerithium* (? *Cerithiopsis*), *Trochus*, *Turbo*, *Pleurotomaria*, *Trapezium*, *Pecten*, and *Spondylus*. Of these it will be seen that six range to over 600 fathoms, and that the only genus at present confined to shallow water is *Trapezium*. *Apropos* of this and the genus *Plicatula*, it must be remembered that none of the species survive to the present day, and that there is no reason why the Cretaceous species should not have ranged into deep water. Referring to modern deep-sea forms, Mr. E. A. Smith has remarked that they do not present any very special characters, and that in many cases "the same species is equally well adapted for living in deep or shallow water, and as far as our observations have reached, the shells appear to be very little affected by the difference of the depth or the nature of the bottom."*

Mr. Woods puts the depth of water below which the Chalk Rock was formed as somewhere between 100 and 500 fathoms. He points out that if it had been less than 100 the genera would almost certainly have been represented by a larger number of species, for though there are a number of genera each genus is only represented by one or two, at most three, species; and that if it had been more than 500 fathoms the number of individuals would have been less. I am quite prepared to accept this conclusion, but think it unlikely on general grounds that the water was less than 300 fathoms deep.

Little can be learnt from the Brachiopoda or the Echinodermata of the Chalk Rock, as it does not contain any special forms, and the Bryozoa have not yet been worked out.

The Foraminifera furnish better evidence, especially as many of the species have survived to the present day. In the lists given on

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* Challenger Exp. Report on the Lamellibranchiata, Vol. xiii. p. 5.

p. 349 to 353 there are no fewer than twenty-five species recognised by Mr. Chapman as occurring in the zones of *Hol. planus* and *M. cortestudinarium* which do not recur in the higher zones, if we disregard the exceptional deposits of the Taplow phosphatic Chalk and the Trimmingham Chalk. Of these twenty-five species fifteen survive to the present day; eight of these are species of great bathymetrical range, but the other seven are more restricted. They are:—

Miliolina agglutinans, essentially a shallow water species, and is not found below 440 fathoms.
Gaudryina filiformis, which ranges from shallow water to moderate depths, 620 fathoms being its extreme range.
Spiroplecta annectens, recent specimens have only been found at two localities (140 and 155 fathoms).
Bulimina polystropha, a decidedly shallow water form seldom found beyond 50 fathoms.
Cristellaria tricarinella, only found living at one locality in Torres Straits (95 to 155 fathoms).
Truncatulina culter has a range from 580 to 1,500 fathoms.
Discorbina Berthelоti occurs chiefly at depths of less than 500 fathoms, though does range into deep water.

Two species of *Frondicularia* also occur, and the modern species of this genus are found chiefly between 80 and 600 fathoms, and are rare at greater depths. As to *Truncatulina culter*, it is, of course, very probable that it lives in less than 580 fathoms, though not dredged in less by the Challenger Expedition. The evidence of the Foraminifera therefore tends to confirm that of the Mollusca that the zones of *H. planus* and *M. cortestudinarium* were formed in less than 500 fathoms.

2. Subsidence.

We have next to deal with the zones which overlie that of *Holaster planus*, and form the mass of the Upper Chalk. The zone of *Micraster cortestudinarium* may be looked upon as a zone of passage between that of *H. planus* and that of *M. coranguinum*. In its lithic characters most of it resembles the chalk of the *H. planus* zone, but the quartz-grains are always very small, and glauconite grains are rare or absent. Cephalopoda and Gasteropoda are rare, and it is evident that during its formation the conditions which led to the formation of beds like the Chalk Rock were gradually passing away.

Coming, then, at once to the consideration of the central zones of the Upper Chalk, those of *M. coranguinum*, *Marsupites*, and *Act. quadratus*, we find them presenting a great contrast to the lower beds, and affording evidence that can only be interpreted as indicative of renewed subsidence.

Stratigraphical Evidence.—In England the *M. coranguinum* zone everywhere presents the appearance of having been quietly and continuously accumulated in water that was seldom disturbed by bottom-currents. The chalk is very seldom of a nodular character, and no layers of green-coated nodules have yet been observed except at or above its summit in the Isle of Wight. In Ireland, where there is such a great break in the continuity of the series, sedimentation was recommenced at this epoch, but there the chalk of this zone is sandy and glauconitic, owing to the proximity of land, and it was not till the time of the *Marsupites* zone that pure white chalk came to be formed in Antrim. "The lower beds of the *Inoceramus* zone are limited to the centre of this (eastern) division, but the higher ones overlap the older strata both to the south and north, invading the central area on the one hand and extending to Carnlough on the other." * This overlap and change from calcareous sand to glauconitic chalk, and then to pure white chalk, seems to indicate a considerable and extensive subsidence, carrying back the coast-lines and deepening the water to such an extent that for the first time in the history of the Cretaceous period a deposit of pure chalk-ooze was accumulated in the Antrim basin.

Lithological Evidence.—In these zones the quantity of mineral detritus in the residues examined by Mr. Hill is at a minimum. In the *M. coranguinum* zone the average amount of insoluble residue is only 1·72, and the greater part of such residue consists of fine clay and ferruginous matter. With a single exception the amount of coarse residue varies from ·005 to ·036, the exception being in Yorkshire (Kirk Ella), where it amounts to ·105, but this is due to the presence of silicified shell-fragments, and not to detrital minerals. In other cases most of the coarse residue consists either of arenaceous Foraminifera or of small lumps of porous oxide of iron. A few minute grains of quartz generally occur in the residue, but so few that they can always be easily counted, and their average size is only ·13 mm., none larger than ·46 being seen.

In the zone of *Marsupites* the coarse residues exhibit similar characters; in amount they vary from ·003 to ·02, and the average size of the grains is only ·07, the maximum size being ·19.

The same is the case in the zone of *Act. quadratus*, samples from the south of England all having less than 1 per cent. of insoluble residue, the coarser part varying from ·001 to ·05. A few minute quartz-granules are generally present, their average size being ·08 mm.

Only in Yorkshire are the total residues larger than elsewhere, and this is due to a larger proportion of fine clay in the flintless chalk of the zones of *Marsupites* and *Act. quadratus*.

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* W. F. Hume on the Cretaceous Strata of County Antrim, Quart. Journ. Geol. Soc., Vol. liii. p. 601 (1897).

Such lithic characters as those above mentioned are comparable to those of recent oceanic deposits formed at a great distance from land, and in which the quartz-grains are merely quartz-dust originating over some dry tract of land and blown out to sea during dust storms. One point may here be noticed, and that is the absence of even the minutest fragments of volcanic minerals in the chalk of these zones. In this respect it differs from almost all samples of modern Globigerina ooze, in which volcanic débris is almost always found. The Upper Chalk is, in fact, a more purely calcareous deposit than any modern calcareous ooze, and we may infer that no active volcanoes existed at this time anywhere in the region of Northern Europe or of the Northern Atlantic.

Zoological Evidence.—The Molluscan fauna of this part of the Upper Chalk (zones of *M. coranguinum*, *Marsupites*, and *Actinocamax quadratus*) has a character of its own which is not without its significance. In the first place, Gasteropoda are of very rare occurrence; of all those found in the Chalk Rock only *Pleurotomaria* survives, and the only other yet discovered in England is *Hipponyx Dixoni*. Even the lamellibranchiate fauna is not a large one, so far as genera are concerned, though individuals are often abundant. The principal genera are *Avicula* (2 or 3 species), *Inoceramus* (8 species), *Lima* (4 species), *Septifer* (1 species), *Ostrea* (10 species), *Pecten* (7 species), *Neithea* (2 species), *Pinna* (1 species), *Spondylus* (5 species). It will be noticed that all these are genera belonging to the allied families of Ostreidæ, Pectinidæ, Mytilidæ and Aviculidæ; also that, with the exception of *Inoceramus*, *Ostrea*, and *Pecten*, none are represented by many species.

The rarity of dimyarian genera is remarkable, for in the deep waters of modern oceans they are at least as common as the Monomyaria, the principal modern genera being *Callocardia*, *Cetoconcha*, *Cuspidaria*, *Lyonsiella*, *Abra*, *Verticordia*, *Miocardia*, *Nucula*, *Nuculana*, and *Arca*. The absence of some of these genera may perhaps be accounted for by the fact that the shells of the first five above named are so thin that in all probability they would not long remain undissolved on the ocean floor, and thus would not be likely to occur as fossils in a deposit which had been formed at a great depth (600 fathoms or more). *Verticordia* and *Miocardia*, which have fairly thick shells, may not then have existed, since they are only known as fossils in Tertiary deposits.

Nuculana, *Nucula* and *Arca*, however, certainly existed in the Cretaceous period, and their absence is not so easily accounted for: it may well be, however, that their shells are less durable and less resistant to solvents than those of *Ostrea*, *Pecten*, *Pinna*, and allied genera. To test this possibility I have made a rough experiment with single valves of recent *Nuculana* and *Pecten*. Valves were chosen of nearly equal weight, and each was put in an egg-cup with an equal quantity of water to which five drops of strong hydrochloric acid was added. The *Nuculana* was completely dissolved in the course of ten minutes, while the *Pecten* retained its shape at the end of twenty minutes, just broke when touched at the end of twenty-five minutes and was not wholly dissolved at the end of fifty minutes. This result was so suggestive that another trial was made but in this the difference was less.

When, however, we remember that both *Arca* and *Nucula* are not uncommon in the Chalk Rock, their absence in the higher zones seems most reasonably accounted for by disintegration previous to complete embedment; if it had taken place subsequently casts would have been left, as in the Chalk Rock.

I conclude, therefore, that we must not regard the fossil fauna of the zones of *M. coranguinum*, *Marsupites*, and *Act. quadratus* as presenting us with a complete assemblage of the Molluscan life then living on the ocean floor, but rather as being only those shells which, by reason of their strong calcitic structure, were enabled to resist the disintegrating influences operating at such depths.

We may next consider the Bryozoa, which have been invoked by M. Cayeux as forbidding us to consider any part of the Chalk as a deep-water formation.* He has attempted to compare the bryozoan genera of the Upper Chalk of France with those of the modern genera recorded by Mr. Busk in his monograph of the Challenger material. The French Bryozoa referred to by M. Cayeux came chiefly from the zones of M. *coranguinum* and *Bel. mucronata* and of the genera enumerated only sixteen are mentioned in Mr. Busk's monograph. Of these genera nine now live at depths of less than 150 fathoms, while seven have species which exist only in greater depths, but the number of deep water species is less than the number of those which are restricted to shallower water (within 150 fathoms). He considers this evidence to be sufficient indication that the Chalk was not formed in deep water; and he further points out (p. 500) that, this being so, the Echinoderms, which so often bear Bryozoa on their tests, cannot be cited as indicating any great depth of water.

In this argument there are two weak points: (1) His data are obtained chiefly from two zones only, to the exclusion of the others, and yet he draws conclusions as to the Upper Chalk as a whole. (2) The generic nomenclature of the Bryozoa is at present in such confusion that no such comparison can be relied upon until the nomenclature has been revised.

Knowing that Dr. J. W. Gregory was engaged upon such a revision of the fossil Cretaceous Bryozoa, I asked him if he could express an opinion on the question, and he replies as follows: "The Bryozoa of the zones of *Hol. planus* and *Micr. cortestudinarium* might have lived at a depth of 100 fathoms, or of as much

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*** Contributions à l'Étude Micrographique des Terr. Séd., 1897, p. 501.**

as 600 fathoms, possibly even rather more, but there are other zones in the Chalk in which Bryozoa are rare, and these were probably formed in deeper water than the *cortestudinarium* zone."

The last remark is significant, especially when the relative abundance of Bryozoa in different parts of the Upper Chalk is considered. They are very abundant in the zone of *M. cortestudinarium* and in the lower part of the *M. coranguinum* zone. With respect to the other two zones I have consulted Dr. A. Rowe, of Margate, who has paid special attention to the Bryozoa and their distribution; he informs me that in the zone of *Marsupites* they are sometimes fairly common, but in other localities they are rare, that the zone of *Act. quadratus* is generally rich in them, but not invariably so. With regard to the zone of *Bel. mucronata*, the evidence at present available tends to show that its lower part is not very rich in Bryozoa; whether the higher part is richer has not been definitely ascertained but in the Trimingham chalk they are certainly abundant.

It will be seen, therefore, that the testimony of the Bryozoa, so far as it goes, is strongly suggestive of a gradual subsidence, culminating in the zone of *Marsupites* when the depth of water was greatest and consequently least favourable to abundant bryozoan life; and, further, that there was subsequently a recovery from this subsidence, till the water was sufficiently shallowed to be once more favourable to their existence.

The only other class of animals which seem likely to afford evidence on the question before us is that of the Foraminifera. Referring to the list of Upper Chalk species given on p. 349, it will be found that Mr. Chapman has determined 88 species from the zones we are now discussing.* Of these 46, or rather more than half, still survive, and it is significant that no less than 35 of them are species which range into deep water, *i.e.*, into depths of more than 1,000 fathoms. Only 11 are species which, up to the date of Mr. Brady's Challenger Report (1884), were not known to occur in depths of more than 700 fathoms; these are the following:—

Species.	*Range given.* Fathoms.
Rhizammina indivisa	150 to 540
Textularia turris	350 „ 390
„ trochus	0 „ 390
Verneuilina triquetra	89 „ 390
Gaudryina filiformis	0 „ 620
„ rugosa	0 „ 675
Tritaxia tricarinata	„ 155
Nodosaria aculeata	95 „ 405
„ filiformis	50 „ 450
Ramulina globulifera	95 „ 620
Pulvinulina concava	0 „ 150

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*Excluding those found in the Phosphatic Chalk of Taplow, which will be referred to in the sequel.

Since the date of the Challenger Report, ***Textularia turris*** has been found at 438 fathoms and ***Gaudryina rugosa*** at 936 fathoms, both in West Indian waters; moreover, several of the species are rare as recent forms and may at any time be found at greater depths than those at which they were obtained by the Challenger Expedition. Thus we may safely say that the range of ***Tritaxia tricarinata*** is unknown, for it has only been found living at one locality; as it ranges through every part of the Chalk and is associated with species which are now commonest in deep water, there can be little doubt that in the Cretaceous period, at any rate, it had a considerable range in depth. Excluding the ***Tritaxia***, there remain six species which at the present time have only been obtained at depths of less than 500 fathoms. This fact must be taken for what it is worth, but it is of the nature of negative evidence, and the positive evidence of the Foraminifera found in these zones of the Upper Chalk is decidedly in favour of their having been laid down in water of greater depth than prevailed during the formation of the zones of *H. planus* and *M. cortestudinarium*.

This statement, however, will not apply to the assemblage of Foraminifera found in the phosphatic chalk of Taplow (see p. 219), which is remarkable not only because it is very rich in Foraminifera, but because so many of the species have not been found elsewhere. Thus Mr. Chapman distinguished no fewer than 99 different species;[*] of these five were described as new species, and of the rest 30 were not previously recorded from any part of the Chalk, while no fewer than 44, or nearly half, have not yet been recorded from any other bed in the Upper Chalk. Among those species which have survived to the present day 13 are either shallow water forms or appear to have a very limited range in depth; these are:—

Spiroloculina limbata -	Shallow water, rare beyond 400 fathoms.
Miliolina trigonula -	Shallow water, rare beyond 500 fathoms.
Textularia conica -	Shallow water to 142 fathoms.
Bolivina nobilis -	Ranges from 6 to 400 fathoms.
Nodosaria aculeata -	Ranges from 95 to 450 fathoms.
„ hispida -	Ranges from 95 to 450 fathoms.
„ Rœmeri -	In less than 400 fathoms (N. Atlantic).
Lingulina carinata -	Ranges from 40 to 580 fathoms.
Cristellaria gemmata -	Rare but only found between 95 and 210 fathoms.
Pulvinulina Karsteni -	An Arctic species from less than 220 fathoms.
„ repanda, var. concamerata.	Found in less than 150 fathoms.
„ punctulata -	Ranges from 10 to 390 fathoms.
Rotalia Beccari -	Essentially a shallow water form.

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[*] Quart. Journ. Geol. Soc., Vol. xlviii. p. 514 (1892). In this paper 98 is the number mentioned, but Mr. Chapman informs me that ***Tritaxia foveolata*** was unintentionally omitted.

Eight of these are essentially shallow water forms, and yet others are associated with them which are just as characteristic of deep water, such are *Miliolina venusta, Rhizammina algæformis, Verneuilina pygmæa,* and *Rotalia Soldani.*

Such discordant evidence can only be explained on the supposition that the shallow water forms had been transported to the spot where they are now found, and the most probable means of transport is that of a current, as was first pointed out by Mr. Strahan.* There are other facts connected with the deposit which suggest the action of a current; the underlying floor of indurated chalk, the abundance of remains of small fish, and the phosphatisation of the shell-fragments and the Foraminifera. The explanation of all these facts is probably that suggested by Mr. Strahan—namely, a temporary "change in the strength or direction of the local currents"†; but I think we may go further than his cautious and general statement, and may attribute the phenomena to the action of a strong current setting out from shallower water and temporarily directed over this spot. In all probability this current carried along dead and decomposing organisms of various kinds, and this food supply was accompanied by a swarm of small fish who followed it into deep water. Further, it seems most probable that this current set southwards from a northerly direction, for three of the Foraminifera have a remarkable distribution at the present day, *Pulvinulina Karsteni* being only known from Arctic seas, *Pulv. concamerata* only from British seas, and *Nodosaria Rœmeri* being found chiefly in the North Atlantic. Such a current will also account for the phosphatisation, for phosphatic nodules are mostly found in localities where currents cause the meeting of waters of different temperatures.

I would, however, guard myself against being understood to suggest that the imported Foraminifera were brought from really shallow water in the neighbourhood of a shore-line; it will be seen that all of them range to 150, and many of them to 400, fathoms, and it is quite possible that some part of the sea-floor to the northward rose into a submarine bank, parts of which may have reached to within 100 fathoms of the surface, but were still at a considerable distance from land, exactly as Rockall Bank does at the present day. In this I agree with Dr. Hume, who regarded them as "transported by current action, not from a shore-line, but from considerable depths, and that this explains the absence of any mineral materials,"‡ and with Mr. Strahan, who writes: "From whatever direction it (the rock material) was drifted, it must have been from a region almost unreached by mineral sediments."§

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* On Phosphatic Chalk, Natural Science, Vol. i. p. 284 (1891).

† Quart. Journ. Geol. Soc., Vol. lii. p. 468 (1896).

‡ Dr. Hume in Proc. Geol. Assoc., Vol. xiii. p. 239 (1894).

§ Natural Science, Vol. i. p. 285.

3. Re-Elevation.

We have finally to consider the contents of the zones of *Belemnitella mucronata* and *Ostrea lunata*, and to see in what respects they differ from those of the underlying zones.

(1) *Lithological Evidence.*—Mr. Hill and Dr. Hume have described the residues of five samples from the zone of *Bel. mucronata* and the quantity of detrital material is still very small, but seems to be variable, and in some of the samples, grains of detrital minerals are more numerous in the coarse residue than in any sample from the two underlying zones. It is noticeable too that grains of felspar occur in two of them, and that in the residue of the Norwich chalk Mr. Hill mentions "an appreciable amount of sand."

In the Trimingham chalk not only is the total quantity of residue large, but half the coarse residue consists of fine sand, composed chiefly of quartz, but including grains of felspar, mica, rutile, tourmaline, and zircon. In this respect, as well as in the presence of glauconite, and in abundance of shell-fragments and of Foraminifera, this chalk resembles that of the zone of *Holaster planus* more than any other part of the Upper Chalk; it differs, however, in the much smaller proportion of glauconite, and in the more minute size of the mineral grains.

The evidence above indicated distinctly favours the hypothesis that a movement of elevation was in progress during the formation of these beds.

(2) *Zoological Evidence.*—With respect to the Mollusca, it will be noticed that Cephalopoda are more numerous, six species of *Ammonites* having been found in the Norwich Chalk, together with species of *Baculites, Crioceras, Heteroceras* and *Nautilus*, the reappearance of these genera recalling the fauna of the Chalk Rock. No doubt their presence merely means that there was more food for these animals, but then why was such food more abundant?

More significant is the recurrence of several genera of Gasteropods; individuals are rare, but representatives of the following have been found, *Avellana, Aporrhais, Dolium* (?), *Emarginula, Hipponyx, Nerinæa, Pleurotomaria, Turbo,* and *Turritella.* The presence of these in the zone of *Bel. mucronata* shows that their absence in the underlying zones cannot be attributed to the solution of their shells after the elevation of the Chalk into Tertiary land, but must be due to some contemporaneous condition which prevented their embedment. If this condition was a great depth of water, as already suggested, then their occurrence as casts in the *Bel. mucronata* chalk may be taken as indicating a lessened depth of water, allowing such shells to last long enough for complete embedment.

Among Lamellibranchs the reappearance of *Cuspidaria caudata* has a similar significance, the occurrences of this shell being especially remarkable; it has been obtained from the Chalk Marl (base), from the Chalk Rock, and from the Norwich chalk, and from these horizons only, yet its recurrence shows that it existed throughout the whole period, and until a specimen is discovered in the zone of *Terebratulina*, or in one of the three middle zones of the Upper Chalk, its preservation in Chalk Rock and in the zone of *Bel. mucronata* may fairly be regarded as something more than an accidental coincidence.

The reported recurrence of *Pholadomya* is also worth notice, for if correct, it is the only occurrence of this genus above the zone of *Holaster subglobosus*. It is a deep water shell, and a recent species has been obtained down to 1,100 fathoms (Fischer), so that its non-appearance in the other zones is the more surprising. On the hypothesis above suggested, its absence from certain zones is comprehensible, but one would expect it to occur in the zone of *Holaster planus*.

With regard to the Bryozoa, little can be said, as they have not been specially collected from the Norwich Chalk.

Neither do the Foraminifera, so far as they are at present known, afford any decided evidence of a decrease in the depth of the sea. The total number identified by Mr. Chapman (see p. 337) is 53, and of these 22 are still living, but nearly all of them are species which range from shallow to deep water.

Coming now to the Trimingham Chalk, which I have separated from the Norwich Chalk under the name of the zone of *Ostrea lunata*, we find several members of its fauna worthy of notice. As in the Norwich Chalk, *Ammonites* and *Baculites* are found, and at least two genera of Gasteropods (*Cerithium* and *Turbo*). Among Lamellibranchs there are *Arca Geinitzi* (which probably also occurs near Norwich) and *Nucula pectinata*, a species which was not known to range above the Chalk Marl in England, but which was identified by Professor Deecke among the fossils collected by Mr. Brydone (see p. 266). This species evidently persisted throughout the whole Upper Cretaceous period, and the non-existence of its shell in the great mass of chalk which lies between the Chalk Marl and the Trimmingham beds is a fact which demands explanation. Either it was a species which only lived in moderate depths, or, if it could and did live in deep water, its shell was destroyed before its embedment was complete. In either case this *Nucula* may be expected to occur in the zone of *Holaster planus*, now that it has been discovered in that of *Ostrea lunata*.

Nucula pectinata has been found in the marls and sandstones which represent the Turonian and Lower Senonian stages in Bohemia, a proof that it persisted with other Cenomanian species in the shallower waters of the Cretaceous sea.

With respect to the Bryozoa, we are not yet in possession of sufficient evidence, but Mr. Brydone informs me that these are abundant and that many of the species are identical with those of the chalk of Rügen in North Germany.

The Foraminifera have not yet been fully investigated, but among those isolated by Mr. Hill and examined by Mr. Chapman 34 species were identified, and of these 24 are still living, and this is noteworthy, as being a larger proportion of living forms than is the case with any other part of the Chalk. When the ranges of these species are considered, however, the evidence is found to be conflicting and inconclusive. Thus there are two essentially shallow water forms, *Polymorphina communis* and *Discorbina globularis*; on the other hand, these are associated with *Bulimina exilis*, *Pullenia spheroides*, and *Rotalia Soldani*, which are more especially characteristic of deep water.

Textularia sagittula may also be mentioned, for, though it now ranges into deep water, it has only yet been recorded from two other localites in the Upper Chalk, Taplow (zone of *Act. quadratus*) and Lewes (zone of *Micraster cortestudinarium*). and is in both cases associated with some species of limited range.

Concluding Remarks.

From the facts mentioned in the preceding pages it will be gathered that there is a certain amount of evidence in favour, of the conclusions predicated on p. 361. The evidence of upheaval during the formation of the *Holaster planus* zone is strong, that of the subsequent subsidence is fairly definite, but the indications of re-elevation to be found in the zones of *Belemnitella mucronata* and *Ostrea lunata* are not quite so cogent. With respect to the last, no one will be disposed to doubt that the Cretaceous period did actually close with such a movement of upheaval, even if it had not proceeded very far at the time when the English record of Cretaceous history breaks off, for we must remember that the final members of the Cretaceous Series are wanting in this country, having been destroyed by the erosion which preceded the deposition of the Eocene Series.

Dr. W. F. Hume, writing on the "Genesis of the Chalk" in 1894,* published a diagram to illustrate the relations which he believed to exist between the varying lithological characters of the Chalk zones, and the probable depth of the water, and as my examination of the evidence tends to confirm the general idea expressed by his diagram, I have adopted a similar method of showing the probable variations in depth which took place during the formation of the Middle and Upper Chalk.

It must be understood that this is only a diagram, and that it is not to be taken as indicating any belief that that maximum subsidence of the English area in the Cretaceous Period was 700

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* Proc. Geol. Assoc., Vol. xiii. p. 240.

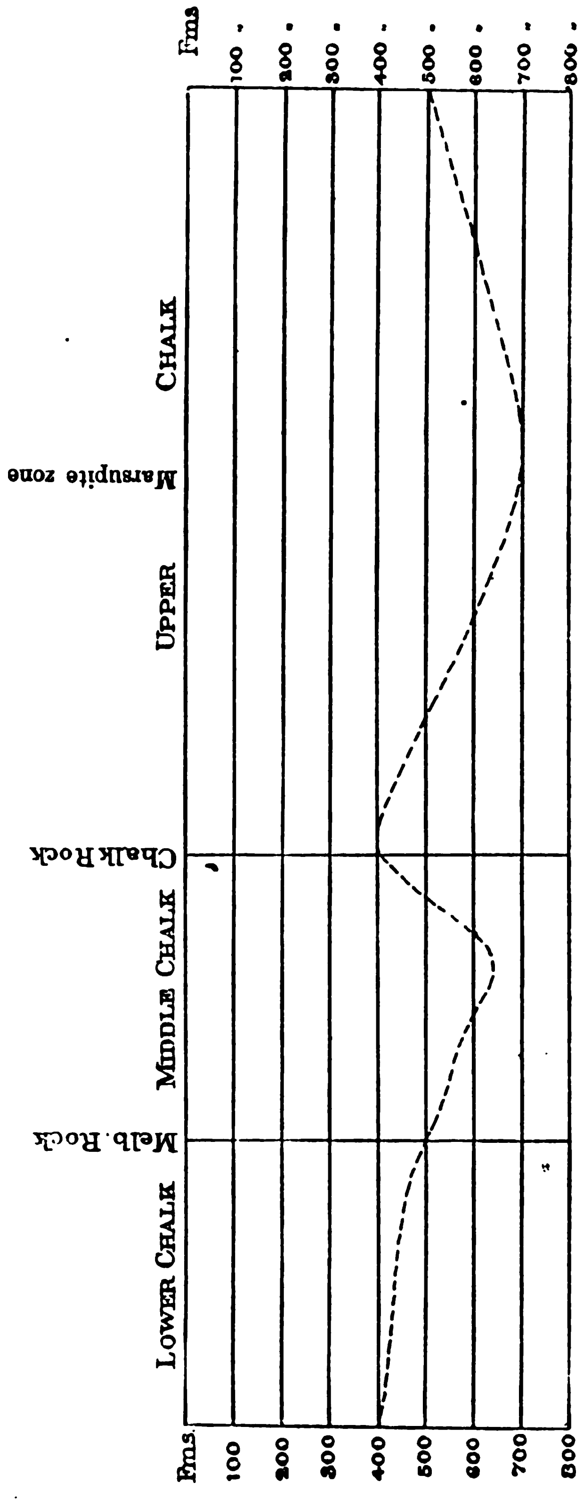

Fig. 68.—Diagram of the probable bathymetrical variations during the deposition of the Middle and Upper Chalk.

fathoms, neither more nor less. The line is drawn down to 700 fathoms merely to indicate the probable extent of the depression as compared with the preceding amount of elevation.

Dr. Hume (*loc. cit.*, p. 239) has suggested that the relative abundance of flint nodules may have had some relation to the depth of water in which the beds were laid down, and he points to the reduction in the size and number of the flints in the *Marsupites* zone as possibly coinciding with the period of maximum subsidence. The rarity of flints in this zone is not invariable, for they are fairly abundant and of moderately large size in these beds throughout Dorset and Wiltshire, but in the eastern part of England it does seem to be the case that they are fewer than in the zone below. In Yorkshire both the zone of *Marsupites* and that of *Act. quadratus* are flintless, but elsewhere flints are of regular occurrence in the latter zone, so that it is doubtful whether the relative abundance of flints can be taken as having any connection with a supposed decrease in the number of siliceous sponges beyond a certain limit of depth.

ADDENDUM.

When discussing the conditions under which the White Chalk was formed, in Chapter XLVI. of Volume II. of this Memoir, I omitted to notice a paper by Dr. A. S. Woodward on "The Antiquity of the Deep-Sea Fish-Fauna."[*] *In this he remarks that "among yfshes it is usually possible to distinguish the deep-sea forms by their comparatively delicate skeleton or by their attenuated fin-rays, or by indications of a great development of the slime canal-system which is related to the production of luminosity or even to the formation of special luminous organs. Judged by these criteria the majority of the deep-sea fishes of the Cretaceous period are more or less closely related to the Scopeloids and Berycoids, which still form so conspicuous an element in the abyssal fauna. They are best known thus far from the Chalk of England and from equivalent deposits in Westphalia, Bohemia, Dalmatia and the Lebanon." He refers especially to* Dercetis Echidnocephalus, Istieus, *and the Berycoids.*

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[*] *Natural Science, Vol. XII. p. 257. (1898).*

CHAPTER XXV.

ECONOMIC PRODUCTS OF THE CHALK.

1. Building Materials.

Beer Stone.—This stone is only quarried near the village of Beer, in Devonshire, and only one quarry is now worked, but formerly there were others, and it was also quarried in Hooken Cliff, west of Beer Head, where the old adit can still be seen. A similar stone was formerly worked at Sutton, near Widworthy, eight miles north of Beer, and was known as Sutton Stone; this occupies the same stratigraphical position as the Beer Stone, and is undoubtedly an outlying remnant of the same bed, but it has not been found at any other locality.

The thickness of the best beds of freestone which were being quarried west of Beer in 1894 was 12 or 13 feet, and the adit was a tunnel of more than that height opening from the face of the quarry into the large subterranean excavations. The stone here seems to have been worked from the open quarry until the head of chalk above became so great that it was necessary to tunnel for the stone.

Smeaton, in his history of the Eddystone Lighthouse, gives an account of a visit which he paid to Beer about 1750. He says:—"I first visited the quarries at Beare, near the south-east corner of Devonshire, and near the sea coast. I found the bed or stratum of freestone worked here was of considerable thickness, and with so great a cover of earth upon it that it was worked in underground cavities, the superincumbent strata being supported by pillars formed by detached parts of the stratum left standing. Here the stone, which is of the calcareous kind and in point of hardness and texture much like Bath Stone, but whiter, lies in so solid and thick a bed that blocks might be cut out from it of any size required; and though the stratum is very compact (that is, free from fissures), yet it is of so soft and workable a nature that I found the workmen sawing out blocks from the general mass (or posts) with carpenter's saws, which they could do to any dimensions required; and though this stone was capable of being thus wrought, and was so free to the tool, yet I found that it hardened considerably after being exposed to the weather, as was manifest by the buildings that had been erected many years at the village of Beare."

The quarry seen by Smeaton is an old one not now worked, the opening to which is on the south side of the lane, and nearly opposite the existing quarry and tunnel. Smeaton's account is very correct, except in regard to its comparison with Bath Stone, which is of oolitic structure, whereas Beer Stone appears to consist entirely of small fragments of shell very uniform in size. It is yellowish in colour, hardens much on exposure, and is altogether much stronger than Bath Stone, and very much superior to the Caen Stone which was once so much used in England.

The following remarks are quoted from a pamphlet entitled "Observations on Beer Stone," by P. E. Masey, Esq., Architect, and printed by J. Townsend, Exeter, 1882 :—

"The stone has these special advantages—agreeable appearance, fine grain, especially fitting it for delicate carving, and easiness and cheapness of working. It is beyond rivalry the cheapest stone in the market.* Its durability for interior work is undoubted, and for exterior purposes it is at least better than many, and, I think, equal to any."

As regards durability, even in the atmosphere of London, Mr. Masey instances its use in St. Stephen's Chapel, Westminster, the crypt of which he states to be built of Beer Stone, not of Caen Stone, as believed by Mr. C. H. Smith and others. "The church of St. Pancras, Exeter, shows its resistance to deleterious city air for 600 years."

In mediæval times Beer Stone was used far and wide throughout the east of Devon and the adjoining parts of Somerset and Dorset, and even in Hampshire, as in Winchester Cathedral, where Mr. Masey identified it in a portion of William of Wykeham's work of the fourteenth century, and where it had stood well in an exposed position for 500 years. He also remarks:—"Beer Stone was used in the cathedral of Exeter from the Norman period downwards, mostly for interior work . . . . In the cathedral archives the stone is mentioned in 1427 to 1434, and the stone so specified is said to have been used in building the chapter house." Among other churches in which Beer Stone is used may be mentioned those of Charmouth, Lyme Regis, Uplyme, Chard, Colyton, Axminster, Axmouth, Seaton, Branscombe, Ottery St. Mary, Honiton, St. Lawrence Clist, Whimple, and Tallaton.

With respect to the capacity of Beer freestone to resist strain and stress, experiments were made in 1879 by Mr. David Kirkaldy (of 99, Southwark Street, London). Twelve specimens of the stone of four different dimensions were submitted to him and he tested the thrusting stress they would bear with the following results, the figures given being the mean result of three specimens of each size :—

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* I am informed by the managing director of the Beer Freestone Company at Seaton, Devon, that the price of the freestone delivered in London is 1s. 6d. per cubic foot, and elsewhere at proportionately low prices. If the demand for the stone increased a pier could be erected at Beer and water-carriage employed which would still further cheapen the stone.

Dimensions.	Slightly Cracked.			Crushed.		
	Stress.	Per sq. inch.	Per sq. foot.	Stress.	Per sq. inch.	Per sq. foot.
Inches.	lbs.	lbs.	Tons.	lbs.	lbs.	Tons.
6×6×6	75,880	2,106	135·4	90,880	2,522	162·1
12×6×6	69,706	1,938	124·6	84 713	2,355	151·4
18×6×6	70,156	1,933	124·3	87,993	2,424	155·8
24×6×6	66,650	1,874	120·5	83,656	2,352	151·2

In comparison with other stones of a similar character, Mr. Masey gives the following particulars :—

	lbs.
Of *Beer Stone*, a cube one inch square bears a stress of	2·106.
Of *Portland Stone*, a cube one inch square bears a stress of	2·125.
Of *Bath Stone*, a cube one inch square bears a stress of	1·275.
Of *Caen Stone*, a cube one inch square bears a stress of (ranges from)	·577.

From these facts it would appear that in regard to strength Beer Stone is practically equal to Portland Stone, and very much stronger than Bath Stone or Caen Stone. A six-inch cube of Beer Stone can be seen in the Museum of Practical Geology.

Totternhoe Stone.—In former days this stone (see Vol. II.) was largely worked at Totternhoe, in Bedfordshire, and it is still occasionally quarried for building-stone both at Totternhoe and at other places along its outcrop in Hertfordshire, Bedfordshire, and Cambridgeshire. It is eminently suitable for inside work, such as vaulting and moulding, being light, soft, and easily worked when fresh, and lasting very well when protected from rain and frost. For outside carved work it is not suitable, as may be seen by a glance at the worn and broken state of the fine west front of Dunstable Priory Church. For plain walls, however, it is a sufficiently durable stone.

Totternhoe stone is a fine-grained grey-coloured limestone, rather rough to the touch, but not really sandy,, its roughness being due to the minute fragments of shell which enter largely into its composition.

Totternhoe Stone is still employed occasionally, especially for interior mouldings, but, so far as I am aware, it is now only quarried at Totternhoe in Bedfordshire, Arlesey near Hitchin, and Burwell in Cambridgeshire.

At Totternhoe the best stone is in two beds, each about 4 feet thick, and can be worked as a freestone, but the beds are traversed by joint planes, which divide them into cubical blocks; masses weighing a ton can be obtained. The upper beds (9 feet thick) are less hard, and do not stand weather so well as the middle beds, and the lower beds are in thinner courses. The stone is now only worked in the open quarry, but formerly adits were driven into the hill along the outcrop of the stone.

Totternhoe Stone has been used in the construction of many of the churches in the neighbouring parts of Bedfordshire, Hertfordshire, and Buckinghamshire. It is eminently suitable for carved and moulded work *inside* such edifices, lasting well if preserved from the weather. Mr. J. Saunders, of Luton, informs me that the tower of the parish church of Luton is built chiefly of alternate cubes of Totternhoe Stone and black flint. It has also been employed in Woburn Abbey, in Fonthill House (Wilts), at Ashridge, and for the organ screen in Peterborough Cathedral.*

The following description of the working of the stone at Totternhoe is from a work by P. Kalm, in which he gives an account of his visit to England in 1748, on his way to America.† Mr. Joseph Lucas translated this work into English, in 1892 ‡ but it is from the MS. which he kindly lent me before publication that this account is taken :—

"This freestone is dug deep under the hills. Here were three places, where they had formerly hewn the same, and where adits down at the foot of the hill went far under the earth, or the Chalk hill. I was as far in as the ends of two, one of which went as far as 40 poles (=660 feet). . . . At the entrance the adit was walled for about 12 feet, to keep it free from slips. After getting about 40 feet into the mine there was no more daylight, but it was coal-black darkness, as of night. The breadth of these adits underground was for the most part 6 feet, the height 7 feet. . . . The water now trickled down everywhere through the roof, or vault of the adit, from the hill above . . . Both roof and walls were very uneven, for sometimes the sides projected and sometimes went in hollows. . . . The adits . . . went most horizontally, yet they sloped a little down in some places. On both sides of the main adit there went other adits, both at acute, right and obtuse angles; so that if the entrances of all these cross-galleries had been open there would have been, to one unacquainted with them, the worst labyrinth and maze there could possibly be; but these adits were now mostly filled up with the loose bits of freestone which had been broken off in the process of hewing.

"The stone divided itself here in the mine all in cracks or fissures, which all went from above downwards more or less perpendicularly, but no fissures ever ran horizontally or very obliquely, which was the unanimous account of the workmen.

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* See Report on the Selection of Stone for the New Houses of Parliament, 1839.

† En Resa til Norra America . . . . . Tom. i. pp. 288–293. Stockholm, 1753.

‡ "Kalm's Visit to England," pp. 292–296 (Macmillan).

"These fissures were sometimes broad, six inches wide or more, sometimes quite narrow, but nearly all very deep, so that a stick four feet long could be stuck into them without reaching the end of them.

"These stones naturally clear each other perpendicularly on all sides, and form as it were perpendicular sides of cubes and oblongs, but they are never naturally divided horizontally [in other words, the planes of bedding do not show, whilst the joint-planes are marked], but all horizontal division must be effected artificially. When the workmen wish to have a stone broken horizontally . . . they hew with their picks a horizontal line where they wish it to be divided, and then knock wedges of iron into it, by which they spring it loose horizontally to any thickness they please. . . .

"The stone down in the mine, and when it was first hewn, was of a grey . . . colour, and so soft that it could be cut with a knife as easily as a hardened or dry pot-clay . . . but when it had come up to the day and lain for a time in the open air it became very white, although not quite so white as chalk, for it could be seen that there was a considerable difference if one wrote with a piece of chalk on a wall built of this stone. . . . Similarly, it has also the property that after it has come into the open air it always hardens more and more. . . . Hence it is that as soon as it comes out of the mine or stone-pit it is worked . . . while it is still soft.

"We also noticed the occurrence of nodules of pyrites (Crow's gold) and of shells in the stone, and that it was used not only as a building stone, but also 'for window-frames and door-posts, and arches over fire-places, windows, and doors for several kinds of pedestals and pillars, the bottoms of baking ovens, etc.'"

Ordinary Chalk.—Besides the recognised building stones of Beer and Totternhoe, ordinary firm chalk taken from the Lower or Middle stages of the formation has been used for building purposes in many parts of England. I have seen square blocks of chalk used in the outside walls of houses and cottages in Norfolk, Suffolk, Cambridge, Herts, and Dorset, and some of them have stood the weather very well.

The following letter, written by Mr. C. B. Rose, on February 4, 1830, to Mr. S. Woodward, of Norwich, has been published by the grandson of the latter (Mr. H. B. Woodward), and relates to the use of chalk in Swaffham, in Norfolk:—

"From an examination of the monastic and castellated remains of this neighbourhood, it appears to have been extensively used for inside work, not merely for the inner walls dividing the building into apartments, but the inner portion of the outer walls. The walls of the Castle, at Castle Acre, are constructed of chalk, cased exteriorly with flint or other less perishable material. Chalk still continues to be employed in the construction of barns, cottages, farmhouses, garden walls, etc. The hard grey chalk (that without flint) is to be preferred, but the chalk with veins of flint is occasionally used and found to answer; walls constructed of it remain damp a long time, I believe. It is necessary that the mortar is of the best quality, to ensure the durability of the building; and equally necessary that the wet should be prevented from insinuating into the work; for instance, to insure the durability of a wall, it is necessary to have a good coping of brick or tile to protect the upper surface.

"The method of using the chalk is as follows: It is raised by quarrymen in largish masses, and allowed to weather; the hardest and that without flaws (for some portions are disposed to part into laminæ by the frost) is chosen, and squared into the form of a brick, but somewhat longer and about twice the thickness [of ordinary bricks]; these forms are then used as if they were bricks, for the outer and inner layers of the work, the space between being filled with irregular fragments"

Mr. Hill and I found the lower part of the Middle Chalk being quarried partly for building stone in 1886 at Northwold, in West Norfolk, and were informed that many houses in that village had been built of it; also that it stood well if dug and squared in the early part of the summer, and then allowed to get thoroughly dry before being used.

Mr. Skertchly found that the chalk obtained from a quarry by the river about two miles west of Brandon was used for walling purposes, being a moderately hard chalk (probably Middle Chalk); the same is the case with the chalk near Hilborough.

Of the Lower Chalk quarried at Marham, in the same county, Mr. R. C. Taylor has said that it is "sufficiently hard for building, the church, the adjoining abbey, and a tomb within the church, with recumbent figures, having been principally constructed of this material."* (For the quarries at Marham, see Vol. II., p. 212.)

Mr. H. W. Bristow, writing in 1862 of the northern part of Hampshire says,; "The chalk is used in the form of lime, both for building and agricultural purposes, while the harder beds are used for buildings, locally, in all parts of the county."†

Mr. Hill found the upper part of the Middle Chalk being quarried for building material on the north bank of the Thames at Medmenham in 1899 (see p. 212.)

Flintwork.—Flints have been used from very early times not only in the construction of simple walls but in edifices of various kinds, and, as Mr. Whitaker has remarked, "they probably form the most lasting material in the kingdom. They may be seen, in the rough state, in Roman work, as near St Albans, and in many old churches of various dates; but they are also used with better effect after having been dressed to a flat rectangular surface, of which there is a good example in the exquisite little Decorated church of Shottesbrooke, in Berkshire."*

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* Trans. Geol. Soc., Ser. 2, Vol i. p. 378 (1824).

† Explanation of Sheet 12, Mem. Geol. Survey, p. 18 (1862).

When used in the rough for walls, weathered flints picked off the surface of the land, or taken from flint gravels, are just as good if not better than fresh flints, but for faced work it is necessary to get fresh flints from the chalk, as these can be split more readily in any required direction, and black flints have generally been selected for this purpose.

Faced flints are often arranged in patterns and frequently in squares, alternating with blocks of stone, the contrast of black flint and light coloured stone having a good effect. The county of Norfolk is renowned for its flint work, which can be seen in many of its churches and older buildings. The old Bridewell, by St. Andrew's Church, Norwich, erected about 1400 A.D., is a fine specimen of flintwork, of which Blomefield, writing in the middle of last century, says that it is "esteemed the most curious wall of black flints in all England for its neat work and look, the stones being broken so smooth and joined so well."

Mr. S. B. J. Skertchly remarks that in some of the Norwich churches the faced flints have been "very cleverly worked to fit into freestone tracery of the Decorated style."†

Land-flints and gravel flints are still used not only for garden walls but for the walls of churches and other buildings. A very recent instance of such construction is the church at Shernborne, in Norfolk, which has been completely restored at the expense of the Prince of Wales, on whose property it stands. The restoration was completed in 1898, and the vicar informs me that many of the flints were in the old church, and that the rest were obtained from the gravel pits at Bircham; the walls are built almost entirely of them, only a few pieces of "ironstone" (? carstone) being used here and there.

A considerable trade in building flints is still carried on at Brandon, as a survival of the former trade in gun-flints. The following remarks are quoted from Mr. S. B. J. Skertchly's memoir on Gun-flints,‡ and were written in 1876—"The cores from which flakes have been struck are slightly worked up to form building stones, or builders, as they are more commonly called. From their mode of formation they taper towards the end; but they are worked to a level face, if possible, but if any projection exists on the face it is struck off and is then called a 'chip back,' because it has been chipped back to a level face. These, however, are not considered so good as those which have a smooth face struck by a single blow of the quartering hammer. 'Builders' are known under the following designations:—

1. Square black-faced builders.
2. Square mixed coloured builders.
3. Round black builders.

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* Geology of London, p. 500, Mem. Geol. Survey (1889).
† Manufacture of Gun-flints, p. 35, Mem. Geol. Survey (1879).
‡ On the Manufacture of Gun-flints, p. 34, Mem. Geol. Survey (1879).

4. Round mixed coloured builders.
5. Random faced builders.
6. Rough builders.
7. Land Stones.

"The first four are made to size as ordered, but this size is arbitrary, the fifth are called 'randoms,' because they are of any size, and are not assorted. The two last are not cores; No. 6 are irregular pieces broken from the quarter [the quartering or first breaking of the large flints]; No. 7 are merely stones picked from the surface of the ground and built into walls without any dressing

"These flints make a very durable and nice-looking wall. Many of the houses in this district [*i.e.*, Brandon and neighbourhood] are built of them, and when the quoining is of brick the appearance is quite attractive, and possesses none of the heavy look that might have been expected. . . . . The trade in 'builders' is steadily increasing, and their durability and effectiveness, combined with small cost, bid fair to give them a more extensive sale than has hitherto been their lot.

"The prices in the town at present (1879) are:—

For the first four kinds, 4s. per 100.
For random faced kinds, 3s. per 100.
For rough builders 3s. 6d. to 5s. per ton.

In Suffolk, mixed-coloured builders are preferred to black ones."

Specimens of all these kinds of faced flints are preserved in the collection of building stones in the Museum of Practical Geology. It is customary for the maker to mark his initials and the date on one or more of the flints supplied, and Mr. Skertchly states that on All Saints Church, Icklingham, Suffolk, the following marks are seen:—

J B. (James Benstead) 1806.
H. A. (Henry Ashley) 1865.

The marking is done by a series of small indentations made by sharp rebounding blows on a punch, each blow driving out a little bulb of flint.

Near Norwich, many old workings and galleries have been found in the chalk, made evidently for the purpose of extracting fresh flints. One of these was found in 1823, near St. Giles' Gate and was described by Mr. G. W. Featherstonhaugh as consisting of various galleries about 8 feet in height, from 2 to 5 feet in breadth, and occupying a total length of 4,600 feet. It is believed "that the object of this particular working was to extract the flints which were used in great quantity in the construction of the ancient buildings and walls of Norwich; for upon reopening the original entrance, which had been blocked up with ruins, the date 1571 with the name of one of the workmen was found written on the side of the cavern, a year which was stated by Mr. Featherstonhaugh to correspond with a period when the walls of the city are known to have been repaired with flints and various buildings formed of them."*

LIME AND CEMENT.

Lime.—In the eastern and southern parts of England chalk has been very largely used for burning into lime. All portions of the chalk have been quarried and employed for this purpose, but there is a great difference in the qualities of the limes made from different kinds of chalk. The soft pure chalks such as make up the greater part of the Middle and Upper Chalk make what is called a "light" lime, or "common chalk lime"; while the Chalk Rock, the Melbourn Rock, and most part of the Lower Chalk make much stronger limes, that made from some parts of the Lower Chalk being equal to the best "stone limes."

A cubic foot of pure chalk, such as is obtained at Chatham and Stroud, weighs when perfectly dry about 90 lbs., but when it is broken into small pieces for burning, a cubic foot measure will only contain about 63 lbs. of the same chalk. This 63 lbs. of dry chalk will make about 35 lbs. of quicklime.† The dry quicklime thus produced by burning chalk in a kiln will slake if a certain quantity of water be added to it, that is, it will become very hot and fall to pieces, forming a fine white powder. If required for mortar this powder is mixed with sand and an additional quantity of water.

The lime made from pure white chalk, however, does not form a good lasting mortar, and the mortar so made is only suitable for inside work and not for foundations or outside walls. It is the Lower Chalk which has yielded the best and strongest limes, and many large quarries have been opened along the foot of the North Downs for the establishment of limekilns, as in the Medway Valley, at Merstham, Betchworth, and Dorking. The lime from these places slakes more slowly than that made from purer chalks, and makes a stronger mortar, which sets harder and resists damp much better.

Cement.—Of late years a large industry has been established in the making of Portland Cement from chalk-marl in the district between Hitchin and Cambridge.

To explain the rapid development of this industry some remarks on the composition and manufacture of Portland Cement are necessary. This information has been obtained chiefly from the anonymous work on "Building Construction," Part III. Materials, published by Messrs. Rivington and Co.

Portland Cement "is so called from a fancied resemblance in its colour to Portland Stone." It is made either from natural stones or marls which contain the required mixture of ingredients, or from an artificial admixture of these ingredients. These ingredients are from 60 to 80 per cent. of carbonate of lime with 20 to 40 per cent. of clay.

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* Proc. Geol. Soc., Vol. i. p. 35; and Geology of Norwich, Mem. Geol. Survey, by H. B. Woodward, F.R.S., p. 29 (1881).

† Observations on Limes, Cements, etc., by Major-General Pasley, p. 4 (1847).

Natural Portland Cement was until recently made from the burning of the large "cement stones" or calcareous concretions which are found in so many Jurassic clays, such as the Lias, the Oxford clay, and the Kimeridge clay. Most of those found in England contain a large proportion of clay (30 or 32 per cent.), are burnt at a low temperature, and yield a quick-setting cement of no great ultimate strength. Stones containing a lower proportion of clay (about 22 per cent.) occur in the Kimeridge clay of Boulogne, and in the Lias near Rugby; these are strongly burnt and yield a heavy, slow-setting cement of much greater value.

Artificial Portland Cement is made in two ways. That hitherto best known is manufactured on the banks of the Thames and Medway from a mixture of pure Upper Chalk and Alluvial Clay, three volumes of chalk being mixed with one volume of clay, the mixture containing about 76 or 77 per cent. of carbonate of lime and from 23 to 26 per cent. of argillaceous matter. The ingredients are mixed together with water in a wash-mill, and are run off into tanks as "slurry."

In other parts of the country cement is made from hard limestone and burnt shale or clay, the limestone being crushed and mixed in proper proportion with the burnt clay; the two are then ground to a fine powder, which is made into bricks and burnt, and then ground again into powder.

Some portions of the Chalk Marl in Hertfordshire and Cambridgeshire contain just about the requisite amounts of clay and calcium carbonate to make a good cement, and when cement works were first established the marl was used without any admixture. It was found, however, that the quality of the cement so made was very variable, and that this was due to the great variability of the composition of the marl, some layers or portions containing much less lime than others. Consequently, it has been necessary to have analyses made of different parts of the Chalk Marl, and to supply any deficiency of lime by adding a due proportion of some purer kind of chalk. Hence most of the cements now turned out would come under the head of Artificial Cement.

Between Hitchin and Cambridge there are now no fewer than seven cement works, these being at Arlesey, Meldreth, Shepreth (two), Barrington, Hauxton, and Cambridge.

Chalk Marl cement was first manufactured at the Arlesey Brickworks, now the Arlesey Brick and Cement Works, near Hitchin, and I am indebted to the manager of this company, Mr. Noel Shilleto, for an account of the materials used and the process employed at these works.

The marl is obtained from the quarry in which the Totternhoe Stone is exposed, and is consequently the highest part of the Chalk Marl. From the description given in Vol. II. p. 188 it will be seen that two kinds of marl are found here, an upper grey marl and a lower blue marl; these differ considerably in their composition, as appears from the following analyses which Mr. Shilleto has kindly supplied:—

	Lower Marl.	Upper Marl.
Insoluble siliceous matter - - - - - -	28·65	20·08
Carbonate of lime - - - - - - -	57·93	73·94
Alumina - - - - - - - - - -	7·68	3·90
Oxide of iron - - - - - - - -	2·07	1·58
Organic matter, etc. - - - - - - -	3·67	—
	100·00	99·50

Mr. Shilleto states that the composition of the lower marl is variable, and that an analysis of the upper part of it gave 66·5 per cent. of carbonate of lime. The analysis above given was that of a sample from the lowest part.

More complete and accurate analyses by Mr. R. A. Berry have been given in Vol. II. p. 335.

At the present time (1894) cement is being made from the upper (grey) marl just below the Totternhoe Stone, but the lower (blue) marl is equally good for the purpose, requiring only a larger admixture of pure chalk.

The marl is mixed with Upper Chalk obtained from Knebworth, south of Stevenage, only a small amount being required in the case of the upper marl; the mixture is made into a slurry with water, dried artificially, and then burnt.

All the Cambridgeshire Cement Works get their marl from the lowest part of the Chalk Marl, some of them working to within 10 or 15 feet of the "coprolite bed" at the base. It is a curious circumstance that this lower Chalk Marl is more calcareous than the blue marl of Arlesey, containing on an average about 70 per cent. of calcium carbonate. It is probable that a similarly calcareous greyish-marl occurs below the blue marl at Arlesey, but it has not yet been sought for.

I am indebted to Mr. G. P. Gildea, of Shepreth, for some particulars of the manufacture of cement from the marl at the Rhee Valley Cement Works at that place. The works are about 300 yards N.N.W. of Shepreth Station, and the marl is from depths of from 6 to 36 feet from the surface. The marl is by no means homogeneous, and samples from different depths always yield different amounts of calcium carbonate. Mr. Gildea had analyses made from samples taken at every five feet, with the following results, 6 feet of soil and subsoil being first removed :—

Depth in feet from surface of exposed marl.	Percentage of $CaCo_3$.
1	69·88
5	69·45
10	68·60
15	68·16
21	76·31
25	75·45
30	72·40

This lowest sample is about 10 feet above the "coprolite bed." The amounts of the calcium carbonate were calculated from the determination of the carbonic acid, and consequently include any small amount of magnesium carbonate that may exist, but this is not likely to exceed 1 per cent. in any case. It will be noticed that the amount of carbonate in the upper 15 feet varies only between 68 and 70 per cent., but that between 15 and 20 feet down the proportion rises to 76 per cent. ; the decrease in the lowest sample is probably owing to the large amount of quartz-grains, and not to any increase of clay.

Mr. Gildea was the first to ascertain the existence of these variations, and to devise a means of securing a constant strength in the cement made from such variable material. His plan is to dig marl down to a certain depth, and in such quantity as to yield a mixture containing about 71 per cent. of carbonates ; this is mixed with a due proportion of a soft greyish chalk, obtained from a quarry south-east of Foxton, and containing about 91 per cent. of calcium carbonate. The mixture is then ground to a fine powder, so as to ensure its being of a homogeneous texture, this is mixed with water in a wash-mill, whence it runs off as "slurry," and finally dried and burnt in the usual way.

The following more complete analyses of Chalk Marls made by Mr. Henry Bassett have also been communicated by Mr. Gildea, the first being from his Shepreth Works, and the second from Mr. Colchester's Cement Works at Hauxton, near Cambridge :—

——	Shepreth.	Hauxton.
Clay and Silica (insoluble)	18·10	22·20
Oxide of iron and Alumina	7·00	2·50
Lime	41·10	41·34
Magnesia	not detd.	·36
Carbonic Acid	30·80	31·40
Sulphuric Acid	not detd.	·12
Alkalis and loss	—	2·08
	97·00	100·00

Both of them contain about 70 per cent. of calcium carbonate.

CHALK AS A LAND DRESSING.

In former days chalk was very largely employed as a top-dressing on all soils that were deficient in lime, both on clay lands as well as on gravelly and sandy soils. There is no doubt that such soils have benefited very much from its use, and though other applications are now more in vogue it is still employed with advantage in many parts of the eastern counties.

Mr. Whitaker has remarked, "in the tracts where there is much of the superficial deposit known as 'clay with flints,' this application to the land used to be very general, and though sometimes the chalk was brought from a pit, the usual method was to sink shafts in the field and work the chalk in short galleries therefrom. I have been told in Berkshire that one dressing serves for about twenty years."*

A good instance of the value of such treatment came under my notice in 1885, with reference to the land round Britwell Prior in Oxfordshire, which consists of rough flint gravel to some depth, but underlain by chalk. I was informed that early in this century all this gravel-land was open heath, covered with furze, fern, and heather, and that no corn could be grown on it, till Mr. Bulford adopted the plan of sinking pits through the gravel to the underlying chalk, getting up a considerable quantity of the chalk, and strewing it over the land, after the furze had been burnt off and the land broken up. Experiments proved that when this had been done good crops, both of wheat and barley, could be grown, and gradually all the heath-land has been brought under cultivation.

In Hertfordshire and Bedfordshire it was formerly a regular practice to chalk the clayey and gravelly soils, which are so prevalent in those counties on the chalk area, and there are a few places where shafts leading down into bell-shaped pits are still opened for this purpose. A century ago they were more numerous, and have been well described by Mr. Walker in his Report on the Agriculture of Hertfordshire,† from which the following is quoted :—

"The undermentioned method is pursued in chalking land, and the persons employed therein pursue it as a trade. A spot is fixed upon nearly centrical to about six acres of land to be chalked. Here a pit about 4 feet diameter is sunk to the chalk, if found within 20 feet of the surface ; if not the sinkers, considering that they are on an earth-pillar, fill up the pit and sink in fresh places till their labour is attended with better success."

After describing the method by which the earth and chalk are prevented from falling in, and the simple windlass and bucket by which the chalk from below is sent up, he continues—

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* Geology of London, Mem. Geol. Survey, p. 502 (1889).

† Written in, ? 1795 ; reprinted by the Board of Trade in 1804.

"The pit is sunk from 20 to 30 feet deep, and then chambered at the bottom, that is, the pitman digs or cuts out the chalk horizontally in three separate directions, the horizontal apertures being of a sufficient height and width to admit of the pitman working in them with ease and safety. . . .

"One pit will chalk six acres, laying sixty loads on an acre. If more be laid on, and to the full extent of chalking, viz., 100 loads, then a proportionate less extent of land than six acres is chalked from one pit. Eighteen barrowfuls make a load, and the usual price for chalking is 7d. per load, all expenses included, therefore the expense of chalking at sixty loads per acre is £1 15s., and at 100 loads, £2 18s. 4d.

"As the chalk is considered to be better the deeper it lies, the top chalk, particularly if it lies within 3 or 4 feet of the surface, is very indifferent, and only fit for lime or to be laid on the roads, gateways, etc., the chalkers must be directed to lay by the chalk for the first 3 or 4 feet in depth, to be applied to the above purposes. If not wanted for those uses, it is again thrown into the pit."

Finally, Mr. Walker points out the advantages which this system of mining the chalk and barrowing it from the shaft mouth on to the land has over the system of open quarrying, which necessitates the use of horses and carts, and in many cases of carting the material for long distances. He says: "Those who have been accustomed to the marle-carts of Norfolk and Suffolk know what severe work to the teams that business always proves, and what a most heavy expense attends it. Horses of great value are often lamed or destroyed, and the purchase of carts and harness with the wear and tear of both form very heavy articles. The Hertfordshire custom is therefore much to be preferred."

Treatises on the agriculture of Sussex and Kent, written about the same time, bear witness to the same method of obtaining chalk for laying on the land as prevailing in the parts of those counties which are underlain by that formation.*

In Essex also numerous subterranean excavations of a similar shape have been found; they are known as "Dene Holes," and have been the subject of much speculation as to their date of origin and their purpose; some of them may be places of concealment, but it seems probable that others may be pits whence chalk was obtained for the use above indicated.†

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* See especially "Notes on Agriculture," Chap. xviii. (1799), by Mr. John Bannister of Horton Kirby, Kent.

† See Report on the Denehole Exploration at Hangman's Wood, Grays, by T. V. Holmes and W. Cole, Essex, Naturalist, December, 1887. "Ancient and Modern Dene Holes," by Charles Dawson, Geol. Mag., Dec. 4, Vol. iv. p. 293; and "On Deneholes and Bell Pits," by T. V. Holmes, *ibid.* p. 447.

WHITENING OR WHITING.

The manufacture of whitening is an industry which depends mainly on the existence of chalk for its raw material, and it is requisite that the chalk should be as pure and soft and as free from flints as possible. The portions of the chalk formation which are most suitable for the manufacture of whitening are the zone of *Terebratulina* in the Middle Chalk, and the zones of *Marsupites* and of *Actinocamax quadratus* in the Upper Chalk, but other parts of the Upper Chalk have been used in some places.

Whitening is made from the Middle Chalk in Bedfordshire (near Dunstable and Luton), in West Norfolk (Hilborough), in Oxfordshire (near Ewelme), and in Lincolnshire (near Louth).

It is made from the Upper Chalk at Whitchurch and Odiham in Hampshire, at Kintbury in Berkshire, and near Norwich.

The usual method of preparing the material is to break up the chalk that is quarried, and to pick out any flints that may be present; the lumps are then thrown into a harrow-mill and further broken up in water, the finer part being run off with the water into tanks where it gradually consolidates into "slurry," while the coarser part, consisting chiefly of shell fragments and Foraminifera, remains in the mill and is thrown away. When the slurry has become sufficiently thick it is dug out and made into whitening, this being dried in lumps under sheds open to the air.

Kintbury in Berkshire (between Newbury and Hungerford) was formerly quite a seat of this manufacture. Mr. Bristow, writing in 1862,* says: "Chalk is made into whiting at Kintbury, and sent by canal thence in considerable quantities, both in its raw and manufactured state, to Bristol, where it is consigned to the oil and colourmen. . . . . . At Kintbury there are five manufacturers of whiting, one of whom makes about 600 tons per annum, the others about 300 tons each, making a total of about 1,800 tons. Formerly it used to fetch 30s. per ton, but now it only sells for 8s."

From recent inquiries (June 1899), I have ascertained that there is still one whiting manufactory at Kintbury, belonging to Mr. F. J. Tuttle, who informs me that he makes about 300 tons of the material in the year, which is sold at a low price to people in the neighbouring district, but is no longer exported to Bristol.

MATERIALS FOR ROAD-METAL.

Two materials obtained from the Chalk have been largely employed for metalling roads; these are flints and Chalk Rock.

Flints form a good material for roads so far as wear is concerned, and provided the roadway is kept moist; but in summer time, after a spell of dry weather flint-made roads break up into sharp sand and loose sharp stones which are detrimental in various ways, but especially so to rubber-tyred wheels. Flints taken fresh from Chalk-pits are brittle, and much less suitable than flints which have been long exposed on the surface of the fields, or dug from deposits of flint gravel. As such flints are plentiful over large areas of the Chalk country, either as surface accumulations or as "clay with flints," they have been largely used.

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* On the Geology of Parts of Berkshire and Hampshire, p. 17 (1862), Mem. Geol. Survey.

Chalk Rock is of much more local occurrence and has therefore been less widely used. Occurring at the base of the Upper Chalk, and being a hard compact limestone which does not break up, like most kinds of chalk, by exposure to frost, it makes a fair roadway, and it has the advantage of keeping firm and unbroken in dry weather.

Chalk Rock has been quarried for this purpose all along the course of the Chalk escarpment, from the north of Dorset, through Wiltshire, Berkshire, Oxfordshire, Buckinghamshire, Bedfordshire, and Hertfordshire; and also in some of the valleys to the east of the main escarpment.

It is hardly strong enough by itself to stand heavy traffic in winter, and it is said that a mixture of Chalk Rock and flints has proved better in some situations than either of them used alone; but the proportion of rock must be larger than that of flints, and the latter must be broken up into smaller pieces than the limestone, otherwise the flints project and make an uneven surface.

PHOSPHATIC NODULES.

1. *Phosphates from the Chloritic Marl and from the base of the Chalk.*

Phosphatic nodules are very common at this horizon, but vary very much in quantity, colour, and chemical composition in different places; the black or dark brown nodules being generally the richest in phosphate of lime.

They have been dug for commercial purposes at Farnham in Surrey, at Bentley and Froyle in Hants, near Blackgang in the Isle of Wight, and from the bed known as the Cambridge Greensand all along its outcrop from Barton in Bedfordshire to Soham in Cambridgeshire, a distance of about 40 miles. The nodules of the Cambridge Greensand have been derived from the Gault and have therefore been described in the first volume of this memoir. Those of the Chloritic Marl, and at the base of the Chalk in the South of England, are more nearly of the same age as the bed in which they occur.

The phosphate beds in Surrey and Hants were discovered and described by Messrs. Paine and Way,* from whose account the following notes and analyses are taken. The characters of the bed itself have been briefly described in Vol. II. p. 58, but the following analyses show that the green marl (apart from the nodules) contains a certain proportion of phosphatic matter disseminated throughout its substance.

	A.	B.	C.	D.	E.
Insoluble siliceous matter -	21·85	26·25	32·81	26·83	39·59
Soluble silica - - - -	20·18	18·11	29·14	26·30	18·42
Organic matter - - -	6·25	5·95	3·02	2·64	4·12
Phosphoric Acid - - -	7·80	10·38	6·61	9·31	6·89
Carbonic Acid - - -	10·91	10·34	2·30	2·35	4·52
Lime - - - - - -	20·58	19·87	9·53	15·24	9·11
Magnesia - - - -	1·59	·87	1·97	1·43	1·64
Oxide of Iron and Alumina -	8·18	6·18	11·46	13·11	13·55
Potash (not estimated in A, B, D, and E) - - -	—	—	3·10	—	—
	97·34	97·95	99·94	97·21	97·84

The samples of A and B were from the residuum of marl washed out of a mass of the phosphate bed weighing 30 lbs. This residuum was dried and sifted, the analysis A being that of the coarse particles and B of the fine mud. The samples C and D were taken from a quantity of the same marl, not washed, but dried in the mass and then sifted; C is the analysis of the fine portion which passed through; D of that left on the sieve after all the large nodules were picked out: this consisted of indurated pieces of marl and small phosphatic fragments; E is an analysis of the same bed of marl from the parish of Bentley.

The amount of phosphate of lime, calculated as bone earth phosphate in the samples analysed is as follows:—In A=16·08, in B=21·40, in C=13·63, and in D=19·22. It is probable that much of the soluble silica and of the iron and alumina is combined in the form of an easily decomposable silicate such as glauconite.

With respect to the fossils and phosphatic nodules which occur in this glauconitic marl, Messrs. Paine and Way distinguished three different kinds. They give analyses of one of the branching sponges ("alcyonites") and of the reddish brown phosphates, and of a sample of washed fossils of all sorts and sizes.

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* Journ. Roy. Agric. Soc., Vol. ix. p. 56 to 84 (1848).

The analyses are given below and numbered 1, 2, 3, in the order above mentioned.

	1.	2.	3.
Insoluble siliceous matter	7·68	7·18	9·84
Soluble silica		3·28	2·36
Organic matter and loss	4·52	2·49	3·26
Phosphoric Acid	29·87	27·13	27·60
Carbonic Acid	8·77	8·77	6·96
Lime	42·29	39·85	44·56
Magnesia	—	·96	·81
Oxide of iron and alumina	6·87	10·60	4·61
	100·00	100·26	100·00

The proportion of phosphate of lime in these samples, calculated as bone-earth phosphate from the several amounts of phosphoric acid, is given by Mr. Way as 61·30 in the first, as 55·96 in the second, and as 59·60 in the third; but there seems to be some mistake in respect to the last, for 27·60 of phosphoric acid is only equivalent to 56·94 of bone-earth phosphate. There is nearly 20 per cent. of carbonate of lime in the first two, and 15·81 per cent. in the third, there being a considerable excess of lime in this last, which is not easy to account for.

Another general sample of fossils dug from the adjoining parish of Bentley gave as much as 33 per cent. of phosphoric acid, which is equivalent to 68 per cent. of bone-earth phosphate.

The only other attempt to work phosphatic nodules from this horizon in the South of England was in the Isle of Wight. The workings were begun in 1851, near the brow of Gore Cliff, on St. Catherine's Down, but do not seem to have been successful, and were soon abandoned.* The Chloritic Marl, in which they occur, has been described in Vol. II. p. 80, and it seems to have been the upper three feet from which they were extracted, which we have called the Cephalopoda Bed, from the abundance of phosphatic casts of Ammonites and other Cephalopoda. There are also some shapeless nodules and some broken angular fragments of phosphate.

The phosphatic character of these organic remains in the Isle of Wight was first pointed out by Captain Ibbetson, who published, in 1848, a little book entitled, "Notes on the Geology and Chemical Constitution of the Strata in the Isle of Wight," and gave partial analyses of the nodules which had been made by Mr. J. C. Nesbit. The following are selected from these analyses :—

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* See Geological Guide to the Isle of Wight, by Mark Norman, Ventnor, p. 88 (1887.)

——	Insoluble matter.	Phosphoric acid.	Phosphate of Lime.	Equivalent amount of bones.
	Per cent.	Per cent.	Per cent.	Tons.
Cast of a Turrilite - - -	5·	24·26	49·79	90
Cast of an Ammonite - -	6·	21·28	43·68	103
Small spongite nodule - -	17·	20·20	41·60	108
Small spongite nodule - -	9·6	19·13	39·26	114
Cast of Ammonite - - -	10·	23·06	47·32	95
Do. do. - -	9·6	23·44	48·10	93
Cast of Turrilite - - -	21·	17·23	35·36	127
Small nodule - - - -	4·4	20·07	41·60	108
Large nodule - - -	22·	16·60	34·06	132

There is another district in the south of England where phosphatic nodules occur in some quantity at the base of the Chalk, and in a bed which extends over a large area; this is in West Dorset (see Vol. II, pp. 99 and 109).

These phosphates have never to our knowledge been dug for agricultural purposes, nor have any good samples of them been properly analysed. The only notice of them which we have seen is in the paper by Messrs. Paine and Way, already quoted. They describe those found near Sutton Waldron as consisting chiefly of carbonate of lime. " In one field, however, some casts of small Ammonites were found, which contained a high percentage of phosphates. The neighbourhood is, therefore, well worthy of a fuller investigation." (Op. cit. p. 75.)

" At Mintern," say the same authors, " both the marl and its fossils are of a richer character. A partial analysis of them gave the following results :—(1) being a speckled glauconitic marl; (2) fossils and nodules in a brown marl; (3) the brown marl itself; (4) a green sandstone.

——	1.	2.	3.	4.
Silica - - - - - - -	26·68	—	—	—
Phosphate of lime - - - -	11·04	46·74	9·10	6·07
Carbonate of lime - - - -	49·25	18·47	4·13	52·06

Phosphatic nodules, similar to those at Mintern, occur at the base of the chalk over a large area to the westward, and are very accessible near Evershot and in the neighbourhood of Maiden Newton.

Similar nodules occurring at Chard (see Vol. II. p. 119) were tested by Mr. Way, and found to contain 10·16 per cent. of phosphoric acid, equal to 20·97 per cent. of bone-earth phosphate.

2. *Phosphatic nodules at higher horizons in the Lower Chalk.*

There are at least four other horizons in the Lower Chalk at which nodules containing more or less phosphate of lime are found: these are:—

1. Near the base of the chalk in West Norfolk at the bottom of the bed which is known as the "Inoceramus Bed" (see Vol. II. p. 209).
2. Ten feet above the Chloritic Marl at Compton Bay, Isle of Wight.
3. From 30 to 40 feet above the base of the Chalk Marl in South Dorset.
4. At the base of the Totternhoe Stone throughout its course from Oxfordshire to Hunstanton, in Norfolk.
5. In the bed known as the "Rag Bed" in the counties of Bucks, Beds, and Herts (see Vol. II. p. 181).

No analysis has yet been made of the nodules that occur in the "Inoceramus Bed," but samples from the other two horizons have recently been tested for phosphoric acid by Dr. W. Pollard, Chemist to the Geological Survey, with the following results: A being a nodule from the Totternhoe Stone of Arlesey, near Hitchin, and B being one from the "Rag Bed" at Butler's Cross (Chalkshire), near Wendover.

——	A.	B.
Loss at 105° - - - - - - - - - - -	·9	·5
Ignited insoluble residue - - - - - -	8·6	3·6
Phosphoric anhydride - - - - - - -	14·4	10·3

Dr. Pollard writes that the residue was obtained in the following manner: "the substance was weighed (after drying at 105°), dissolved in nitric acid (1·2 of water), boiled to remove CO_2 evaporated to dryness, moistened with strong nitric acid, evaporated again to dryness (to render the silica insoluble), taken up with strong nitric acid and hot water; filtered, washed, filtered, dried, and ignited."

The amounts of phosphoric acid found in these nodules are equal respectively to 31·43 and 22·47 per cent. of tricalcic phosphate of lime.

Another locality where phosphatic nodules have been found in the lower part of the Lower Chalk is Punfield Cove, near Swanage (see Vol. II. p. 95), and of these a complete analysis was made by M. Duvillier for Professor Ch. Barrois.* The following is a copy of this analysis:—

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* See Recherches sur le Terrain Crétacé Supérieur de l'Angleterre par Ch. Barrois, Lille, p. 102 (1876).

Sand and clay	8·40
Soluble silica	1·14
Oxide of iron	1·96
Phosphate of lime	19·91
Sulphate of lime	·91
Carbonate of lime	65·62
Carbonate of magnesia	·89
	98·83

3. *Phosphatic nodules in the Middle Chalk.*

The small nodules or lumps of hard chalk which occur in the Melbourn Rock are probably very slightly phosphatic, but I found a few green-coated nodules in this rock near Maiden Newton, in Dorset, and one of these was sent to Dr. Pollard to be tested for phosphoric acid. It was treated in the same manner as the others above mentioned, and gave the following result:—

Loss at 105°	·4
Ignited insoluble residue	1·5
Phosphoric anhydride	6·8

This amount of phosphoric acid is equivalent to 14·83 per cent. of tricalcic phosphate.

Nodules from the bed at the top of the *Terebratulina* zone in the Isle of Wight (see Vol. II. p. 408) were analysed by M. Duvillier for Professor Barrois, the analysis being as follows*:—

Clay and insoluble matter	2·43
Soluble silica	·72
Oxide of iron	·89
Phosphate of lime	4·48
Carbonate of lime	91·25
	99·77

It will be noticed that the amount of phosphate of lime in these nodules is very small, and that they are practically nothing but indurated chalk.

4. *Phosphates in the Upper Chalk.*

These occur at several horizons, but are most widely distributed in the *Holaster planus* zone, and especially in the beds known as Chalk Rock. A sample taken from a large green-coated nodule, compact and yellowish inside, from the Chalk Rock of Henley, Oxon., was tested by Dr. Pollard, with the following result, the treatment being the same as in the previous cases:—

Loss at 1050	4·3
Ignited insoluble residue	3·7
Phosphoric anhydride	5·0

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* Description Géologique de la Craie de l'Ile de Wight, Lille, p. 19 (1873).

The 5 per cent. of phosphoric acid is equivalent to about 11 per cent. of phosphate of lime.

The phosphatic chalk found in the zone of *Holaster planus* at Southerham, Lewes, has been mentioned on p. 307, and the following detailed description of the rock is taken from Mr. Strahan's account.* "It consists of a white chalky matrix, in which are embedded a multitude of brown grains. In weathered specimens these grains can be washed out with water, but the separation can be better effected by dilute acetic acid, which removes almost all the matrix, but scarcely corrodes the brown grains. . . . The brown grains consist largely of phosphate of lime . . . and resemble those of the Taplow chalk" (see below). Mr. Strahan found that microscopical examination showed a close resemblance between the phosphatic chalks from Southerham and Taplow. He says, "in the former the oval pellets, which were determined as the coprolites of small fishes, are rather more abundant and larger, but proportionate in size to the numerous teeth which occur. The prisms of Inoceramus shell are rather less common, but internal casts of foraminifera form a large proportion of the residues, and small, amber-coloured chips of bone occur equally in both. . . Further details of either chemical or microscopical examination of the rock would be a mere repetition of the account of the Taplow Chalk."

The phosphatic chalk at Taplow had been previously described by Mr. Strahan.† Its stratigraphical position has already been discussed (see p. 219), and part of Mr. Strahan's description was then quoted. A complete analysis of the brown Taplow chalk was made by Mr. Hort Player, and was given side by side with an analysis of the similar phosphatic chalk of Ciply, in Belgium; these are quoted below:—

——	Taplow Chalk.	Ciply Chalk.
Moisture	·7	—
Organic matter	2·3	2·83
Lime	53·7	53·24
Magnesia	—	·12
Alumina and oxide of iron	·9	1·01
Potash and soda	·3	·19
Carbonic acid	28·7	28·10
Sulphuric acid	·7	·89
Phosphoric acid	11·6	11·66
Silica and sand	·5	1·96
Fluorine and chlorine	·7	Traces.
	100·1	100·00

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* Quart. Journ. Geol. Soc., Vol. lii. p. 465 (1896).

† Quart. Journ. Geol. Soc., Vol. xlvii. p. 358 (1891).

From subsequent tests Mr. Player determined that samples taken from the upper and lower brown beds contained respectively 18·6 per cent. and 35·6 per cent. of phosphate of lime. The brown colour of the rock was attributed by him to the presence of a substance which he believed to be humic acid, and his identification was confirmed by analyses made by Dr. Tingle, under the direction of Professor Japp.

Mr. Strahan remarks that a rich specimen of the Taplow rock contains about 65 per cent. of the brown grains, and the proportion of phosphate of lime in the brown grains is about 50·6 per cent. These brown grains, when isolated as a residue by washing and examined under the microscope, are seen to consist of the following particles, stated in order of abundance :—(1) Foraminifera, wholly or partly filled with a brown material; (2) broken prisms of *Inoceramus*-shell, infiltrated with phosphate of lime; (3) angular fragments of amber-coloured material, which proved to be chips of fish bones; (4) little oval pellets, which were identified as the excrement of small fish.

For further particulars regarding this interesting deposit the reader is referred to Mr. Strahan's description, and some of his remarks on the origin of such deposits are quoted on p. 373.

CHAPTER XXVI.

THE PHYSICAL FEATURES OF CHALK DISTRICTS.

Since the Chalk of England and France is a unique formation, lithologically different from all the other great calcareous formations of Western Europe, it is not surprising that its surface features should also present special and peculiar characteristics. The physical features to which it gives rise under the moulding influence of rain and frost, the bold slopes of the chalk escarpments, the rolling undulations of the Chalk Downs or Uplands, and the softly-curving contours of the deep combes and valleys which lie between the hills—all these are features familiar to most Englishmen, and form a peculiar type of scenery which cannot be matched in other parts of the country.

Each of these special sets of features, escarpments, uplands, and valleys merit description and illustration, with some account of the manner in which they have been developed.

Chalk Escarpments.

In this as in other memoirs of the Geological Survey the term escarpment is used in the restricted sense, and is applied only to the terminal or boundary ridge of a formation, or of any definite set of beds, that is to say, it means the ridge and slope along which such a set of beds is finally cut off, and beyond which they do not extend, except in the form of isolated patches or "outliers."* It is also taken for granted that chalk escarpments are what may be termed "hills of recession"; that their frontal slopes have not always occupied their present position, but have gradually receded to it from a much more advanced position. Thus it is assumed that the two great escarpments of the North and South Downs were initiated at a time when the lower parts of the Chalk were continued upward from each side toward the central axis of the Wealden area, and were truncated by a plain of marine erosion.

The slopes of chalk escarpments do not everywhere exhibit precisely the same features; the frontal slope is sometimes a continuous sweeping curve, at another place it is nearly a straight inclined line, and where the beds differ greatly in hardness there are sometimes two or even three escarpments one behind the other. Other differences of slope and absolute height depend upon the inclination of the strata, which are in some places nearly horizontal and in others are inclined at angles of varying amount up to 40° or 45°.

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* See Mr. W. Whitaker, "On Subaerial Denudation," Geol. Mag., Vol. iv. p. 447, and "Geology of London,"Vol. i. p. 488, Mem. Geol. Survey (1889).

The North Downs.—In the south-east of England the escarpments of the North and South Downs are conspicuous and well-known features. The North Downs may be described as really consisting of two hill ranges, starting from the valley of the Medway; the one runs in a S.E. direction to Folkestone, where it is cut off by the sea, the other trends about W.S.W. through West Kent and Surrey as far as Dorking, and then due west to Farnham, where it becomes lost in the undulations of the Hampshire Uplands.

The North Downs form a nearly continuous ridge except where they are breached by the valleys of the larger rivers which rise within the area of the Weald. Viewed from the front their summit ridge presents a nearly even and uniform line, and is rarely broken by any depressions or "passes"; there are in fact only three such notches along its whole length, one at Lyminge, in Kent, one at Merstham, and one at the west end of the Hogsback, near Farnham.

The frontal slope of the North Downs, viewed from any point on the slope, is generally a gracefully curving line, steepest near the top, where the inclination is frequently about 20°.

The actual course or run of the escarpment is seldom straight. Throughout Kent and the eastern part of Surrey it follows a decidedly sinuous line, projecting into promontories and retiring into "embayments," so that in looking along the face of the escarpment the observer does not see a continuous hill-slope, but a series of convex projections between which lie the hidden intervening embayments.

From Dorking to Farnham, however, the course of the escarpment is very nearly straight, especially west of Guildford, where the ridge is known as the Hogsback, and is a straight round-backed ridge with an even slope to the south, without any promontories or embayments. This difference is probably due to the different geologic structure of this portion of the range, for in the eastern area the dip of the beds is generally slight, and the vertical height of the escarpment is great, so that the slope is longer, while along the Hogsback the dip varies from 30° to 40°, and sometimes more.

The highest part of the North Downs is the central portion, between Gatton, near Reigate, and the valley of the Darent, the summit ridge along this tract rising in many places to 800 feet. On the eastern range the highest point is near Deptling (657 feet), and thence to the sea the heights become gradually less. The Hogsback is much lower than the more irregular part of the range, only rising to 500 feet at its eastern end and falling thence to between 300 and 400.

Along the greater part of the North Downs the escarpment ridge is the dominating feature, and from it the ground falls gradually northward till it meets the smaller escarpment of the Eocene Beds. But in the district west of the Medway there is for a short distance a second escarpment, parallel to and behind the main ridge, which has been described as follows by Professor T. McK. Hughes.* "There is a curious feature in the Chalk district south of Chatham. The country slopes northward from the escarpment with the usual characteristics, . . . but there is a second escarpment running S.E. from Chatham, parallel to the true escarpment, for about 3½ miles. On the northern side of this we find the hard beds described (previously, see p. 163), and to these the feature is probably due. From this second escarpment there is a slope to within about three-quarters of a mile of the alluvium, where the Thanet beds come on."

The South Downs.—Of these Mr. Topley wrote as follows†:— "The chalk escarpment has a far more uneven outline throughout Sussex than it has on the north through Kent and Surrey. . . . Very rarely do we find the crest of the Southern Chalk escarpment forming a flat surface, but it has a waved, undulating outline. The hollows are not always deep, but sufficiently so to make walking along the edge of the escarpment a tiring though pleasant task. Generally, the edge of the escarpment is quite bare of any superficial covering; but if, as is the case in Kent and Surrey, there were a covering of clay with flints, a drift map showing this would give a succession of small outliers, whereas, on the north of the Weald this clay with flints often caps the escarpment uninterruptedly for several miles."

The depressions mentioned by Mr. Topley always lead into combes on the southern side of the ridge, and he suggested that the South Down escarpment was in a later stage of development than the northern escarpment, that it had retreated more rapidly since the valleys had been commenced, and by this recession had broken into the heads of these valleys. This may be so, but I think there are other circumstances which should be taken into account. The South Downs are on the whole nearer to the sea than the North Downs; consequently the Chalk valleys have shorter courses with a proportionally greater slope, conditions which would probably cause a more rapid rate of erosion. Again there is a considerable difference in the amount of rainfall; in western Sussex the average annual rainfall along the higher parts of the Downs is stated to be 36 inches.‡ The average amount falling on the North Downs is not so much as this—it is said to be about 27 at Aldershot, and a little less than that at Croydon.

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* Mem. Geol. Survey, Vol. iv. p. 360 (1872).

† Geology of the Weald, p. 265, Mem. Geol. Survey (1875).

‡ See H. R. Mill on the authority of Mr. Symons in "Geographical Journal," Vol. xv. p. 226.

Considering these facts, it seems to me that the process of valley making may have been rather more rapid in Sussex than in Surrey, and consequently the heads of the combes which furrow the southern slope of the escarpment ridge may have been eaten back so as to notch this ridge. Of course, both processes, the recession of the escarpment itself and the excavation of the valleys on its southern versant, must have gone on at the same time, and it is quite possible that both processes have been rather more rapid in Sussex than in Surrey or Kent.

One of the most notable passes through the ridge of the South Downs is that south of Cocking, through which both road and railway has been carried from Midhurst to Chichester. Although the escarpment ridge on each side of this truncated valley rises to over 700 feet, the watershed in the pass itself is only about 350 feet above the sea. Fig. 69 is a section across this valley from west to east, and shows what a deep notch it makes in the continuity of the escarpment.

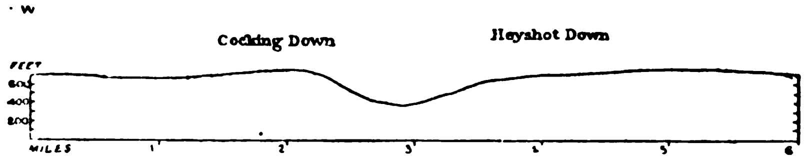

FIG. 69.—Section across the Pass at Cocking.

Based on that given by Mr. H. R. Mill, "Geographical Journal," Vol. xv., p. 221.

The highest parts of the South Downs are in two separate districts, (1) the portion between Buriton and Bignor, where the summit ridge is frequently 750 and sometimes 800 feet above O.D., (2) the range of hills between Clayton and Lewes, which rises in Ditching Beacon to 813 feet.

The course of the South Down escarpment is still more irregular than that of the North Downs, for though its general trend is persistently from west-north-west to east-south-east, yet its continuity is interrupted not only by the great gaps of the rivers Arun, Adur, and Ouse, but also by three remarkable embayments which are due to its intersection by a nearly parallel line or lines of flexure. The first of these is near Bignor, and is due to the influence of an anticline running nearly east and west along the Dean Valley. The next is due to the Greenhurst anticline, which enters the chalk near Poynings, deflecting it to the north for about three miles and producing what may be called the Poynings embayment. The third occurs where the continuation of this flexure passes out of the chalk area, south of Lewes, and this may be called the Beddingham embayment.

These anticlines give rise to a second and subsidiary escarpment, and that portion of the escarpment-ridge which crosses the valleys of the Arun and the Adur is really a part of this more southern subsidiary scarp, the main escarpment which once ran from near Pulborough to Henfield having been completely breached and destroyed.

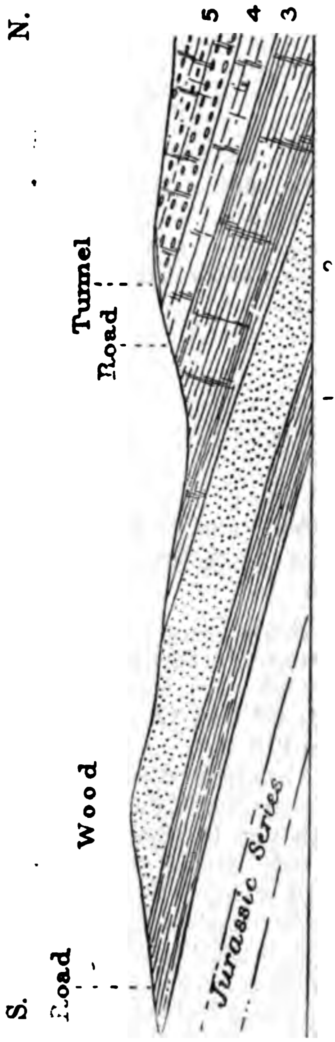

Fig. 70.—Section through the Escarpments near Hinton.

5. Upper Chalk.
4. Middle Chalk.
3. Lower Chalk.
2. Upper Greensand.
1. Gault.

The Vale of Wardour.—The difference which the angle of dip makes in the height and form of a chalk escarpment is well illustrated in the Vale of Wardour (see Vol. II. p. 146). On the south side of the Vale the inclination of the beds is slight, and there is consequently a bold escarpment, consisting mainly of the Lower and Middle Chalk, and rising in most parts to more than 200 feet above the plain at its foot. On the northern side of the Vale the dip is much greater, varying from 10 degrees to 35 degrees, and there is a fault which in some places cuts out part of the Lower Chalk, but even where the Lower and Middle Chalk crop out in complete sequence they do not form an escarpment like that on the other side. On the contrary, their outcrop lies in a narrow valley or trough between the escarpment of the Upper Greensand, and a plain or gentle slope of Upper Chalk.

Fig. 70 is a section across a part of the district which is not dislocated by the fault, and it shows the subsidiary position occupied by the escarpment of the Chalk which is actually dominated by the ridge of the Upper Greensand; this reversal of their usual relations being entirely due to the high inclination of the beds.

The features of the Vale of Wardour appear to have been sculptured out of a plane of denudation which sloped from east to west. When this plane first came under the influence of subaerial agencies the rain which fell on its surface naturally gathered into streams which ran eastward, and the rivers Wily, Nadder and Ebble are the descendants of these streams. The formation of the Vale of Wardour and of its escarpments has been well described by the Rev. W. R. Andrews,* from whose paper the following extracts are taken:—

"On the north side of the district we get continuous relics of the original plain, for the central ridge of the Chalk Downs is there covered with 'clay-and-flints' for a distance of many miles—showing it to be a surface of some age and unlike that of the bare Chalk hills lying below on either side of it.

"That [original] slope we may see by noticing the gradual fall in the height of the Downs, when passing from west to east. Looking at the heights, we find an elevation of 720 feet at the west end of Great Ridge Wood, while there is only an elevation of 520 feet at the east end of Grovely Wood, showing a fall of 200 feet in ten miles, or 20 feet per mile.

"On the south side there are relics of old gravel with pieces of Upper Greensand chert along the top of the Downs, and the same general fall may be observed as on the northern side of the Vale. . . . Over this plain the original stream found its way, taking probably a more serpentine course than it does now." After describing the formation of the Greensand escarpments, Mr. Andrews continues:—"The chalk escarpments of the Vale were started by the erosion of the Nadder as banks when it serpentined over the intervening Greensand, but when the main stream no longer touched their base, as it was kept within the channel it had cut in the Gault, longitudinal streams flowing into the side streams continued the erosion. The water-level at that time stood higher in the Chalk hills than it does now, and issuing as springs flowed right and left, still further cutting away the base of the Chalk. Before the Broad Chalke Valley was cut down so deeply, springs would be thrown along the south side of the Chalk Downs, as they are now on the northern side, and at a much higher level. These lines of drainage are clear along the north side, though they are less clear on the south side, being obliterated by subsequent rain action. While this river-action at the base of the escarpment was going on, landslips, no doubt, often took place, and thus the hills retreated to their present position."

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* Wiltshire Arch. and Nat. Hist. Mag., Vol. xxiv. p. 258, 1891.

Dorsetshire.—This county also presents us with two types of chalk escarpment, (1) that which runs southward from Melbury, near Shaftesbury, and is continued toward the south-west as far as the village of Stoke Wake, where it is again deflected southward to Melcombe Bingham; (2) the western range of Chalk hills between Melcombe Bingham and Cheddington, together with the broken escarpments west of Maiden Newton.

The first of these ranges presents a normal aspect, for though the front of that part which runs south from Melbury Hill is much indented by fine combes, yet its summit ridge is continuous and has a nearly level top sloping very gradually from north to south, and bearing on its surface a gravelly soil of greater or less depth. Its other portion west of the gap through which the Stour runs is less broken by combes and presents a very bold and steep face with a continuous summit ridge capped throughout by "clay-with-flints." It is evident that these ridges are parts of an ancient plane of erosion or denudation.

West of Melcombe Bingham, however, the features of the escarpment are very different, for it is by no means continuous, but is broken by a number of gaps or passes which form the heads of valleys opening southward and occupied by streams flowing in that direction. In some of these gaps the chalk is completely cut through and the Greensand exposed not only on the watershed but for some distance down the valley; this is notably the case in the valley of the Cerne. The brook which is regarded as the head water of the Frome has cut its channel through the Greensand for a distance of more than four miles, from Evershot to Maiden Newton and the Toller brook which joins it at that place from the west has cut down to the same horizon, so that the tract of chalk which extends to the north-west by Beaminster to Cheddington is completely isolated from the rest of the Chalk country and beyond it are a few small outliers which mark the former extension of the Chalk escarpment into Somerset.

If we seek for the cause of this broken-up condition of the western portion of the Chalk escarpment we soon perceive that the general course of the principal valleys in this district is from north to south. It seems tolerably certain that when the courses of these valleys were first marked out the main watershed of the country lay far to the north of its present position.* Here, in fact, the explanation suggested by Topley for the passes in the South Downs is much more obviously true; the valley-system was commenced long before the escarpment had receded to its present position, and the valley-passes which interrupt its continuity are the truncated parts of valleys which once extended much farther northward. We may therefore infer that this portion of the escarpment has receded much more rapidly than the more easterly portion. An examination of its frontal slope confirms this idea, for it is cumbered in many places with landslips, and some of these are of recent date, so that we may even say that the recession of the scarp is still in progress.

Moreover the very same cause above indicated as responsible for the broken state of the western part of the Chalk escarpment will also account for the unbroken condition of the eastern part between Melbury and Stourpaine, for this range must have originated as the bank of a stream flowing southward into the Stour; part of this valley indeed still remains north of Stourpaine, and the Iwerne brook which runs through it may be regarded as the reduced representative of the longer stream which rose somewhere to the west of Melbury Hill. It is clear that a ridge which forms one side of a tributary valley and is parallel to the general run of the drainage system is not likely to be cut back so rapidly as a ridge which crosses the general line of drainage and is traversed by many transverse valleys. The small portion of continuous escarpment west of Okeford has probably been preserved because it lay originally on the southern side of a valley whose waters drained eastward into the Stour.

North Wiltshire.—The Chalk-escarpments of the Vale of Pewsey are of the normal kind and have a general resemblance to those of the North and South Downs, corresponding even in the fact that the northern range has a continuous unbroken summit ridge, while the southern range is much more irregular with at least two gaps or passes besides the wide one which gives passage to the river Avon.

Further north, however, in that part of Wiltshire which lies to the north of the Kennet Valley there is a peculiar arrangement of escarpments which deserves attention. In this district there is an outer escarpment formed of the Upper Greensand and Lower Chalk, and an inner one consisting chiefly of Middle Chalk capped by more or less of the Upper Chalk. The ridge of the outer escarpment attains a height of 700 feet near Clyffe Pypard, falling gradually thence, both toward the south and the east, to levels of about 560 feet. The inner escarpment rises from about 660 feet to heights of nearly 900 feet on Hackpen Hill and Liddington Hill.

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* See The Origin of the Valleys in the Chalk Downs of North Dorset, Proc. Dorset Nat. Hist. and Ant. Field Club, Vol. xvi. p. 5.

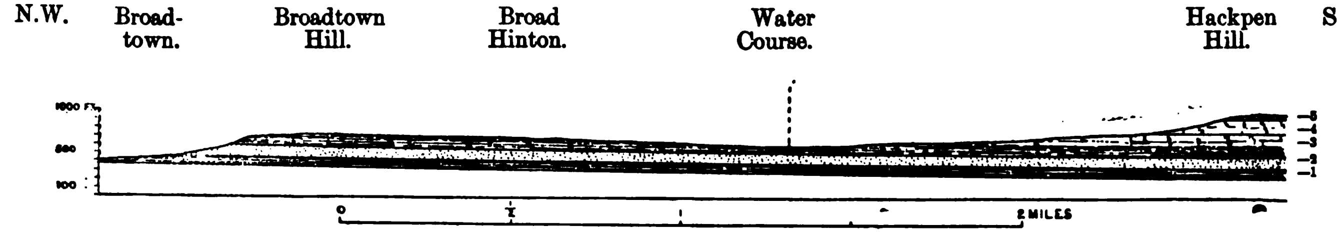

FIG. 71.—Section across the two Chalk escarpments of North Wiltshire.

5. Upper Chalk
4. Middle Chalk
3. Lower Chalk
2. Malmstone }Selbornian
1. Gault }Selbornian

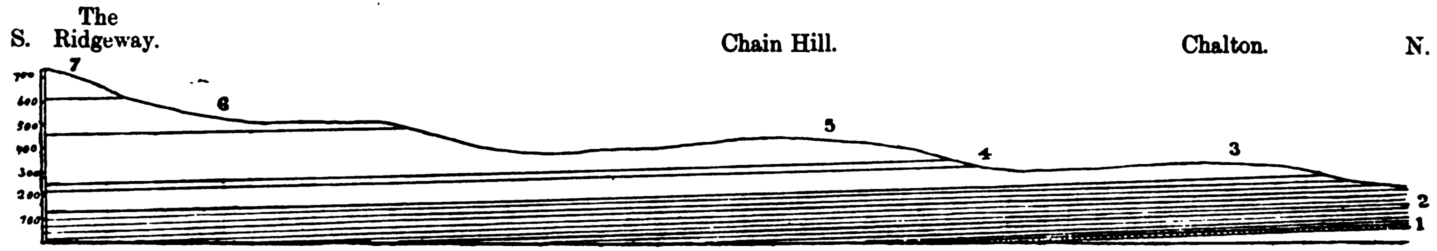

FIG. 72.—Section through the Chalk escarpment near Wantage (Berkshire). Horizontal scale, 2 inches to a mile. Vertical scale, 800 feet to an inch.

7. Upper Chalk
6. Middle Chalk
5. Lower Chalk
4 and 3. Upper Greensand
2. Gault
1. Lower Greensand.

The two escarpments are about five miles apart to the east of Calne, but the distance between them becomes gradually less to the north-east, till in White Horse Hill they are again united in one slope. The cause of this wide separation of the outcrops is not very clear, but the high level to which the base of the Greensand rises on the outer slope may have something to do with it, and we must remember also that the district is part of a great central watershed, whence streams flow westward to the Gloucestershire Avon and eastward into the Thames.

Fig. 71 is a section across these two escarpments along a line where they are about three miles apart, it shows the long and gentle easterly slope of the Lower Chalk to the course of the Winterbourn brook and the gradual rise thence to the scarp of Hackpen Hill, which forms the border of the Marlborough Downs. The surface of the Lower Chalk forms a broad high-level terrace or plateau which varies little in general elevation, but the upper escarpment is a ridge of irregular height and its inner slope is carved out into a series of ridges and combes.

In Berkshire, near Wantage, the Lower Chalk again separates itself from the higher parts of the formation and forms a low subsidiary escarpment (see Fig. 72), while the outcrop of the Melbourn Rock forms a second terrace between that of the Lower Chalk and the summit ridge of the escarpment The width of these two terraces varies much, but they are more or less developed all along the Berkshire outcrop and into the valley of the Thames.

The Chiltern Hills.—In the Chiltern range, and in its northerly continuation through the counties of Bedford and Hertford, the frontal contour of the escarpment varies considerably, but as a rule the outcrop of the Melbourn Rock forms a conspicuous feature and leads to the development of a step or terrace between the slope of the Lower Chalk and that of the Middle and Upper Chalk.

In the more northern part of the range, where the Totternhoe Stone is well developed and the dip of the beds is very slight this bed also forms a feature, and there are then three slopes, each forming the border or descent from a step or terrace of greater or less width.

From the Thames Valley, as far as Bledlow, in Bucks, the escarpment is a continuous ridge, but beyond that its upper level, or the portion above the outcrop of the Melbourn Rock, is broken by broad gaps or passes, which are connected with valleys opening to the south or south-east. These gaps seem to be truncated parts of valleys which were excavated out of the former extension of the Chalk plateau, at a time when the line of its escarpment held a much more advanced position to the north-west. The depressions formed by these truncated valleys cut up the present escarpment into separate blocks, the frontal slopes of which stand out beyond the recesses in which these high-level valleys now terminate.

White Cross Hill, west of Risborough, is one of these projecting blocks, on the slope of which a large cross has been cut out of the short turf. "It is also remarkable for the small conical hills at its northern and southern promontories. To an observer standing on either of these terminal hills it does not seem difficult to understand the method of their formation. Both slopes of the promontories are indented by depressions formed by the detritive action of rain, and leading down into the combes on either side. Two of these depressions have in each case been so widened and extended by the rain directed into them that they have met on the summit of the ridge, and have formed a col or depression across it, so as to cut off the terminal portion of the promontory. The northern hill is still capped by a platform of Chalk Rock, and is united to the main mass by a [narrow] neck of that bed; the other is entirely separated, and only a few fragments remain of its former rock-cap."*

Such semi-detached hills illustrate the manner in which all outliers have been isolated, and also explain the conical form of many hills from which the original capping of hard rock has been removed.

Another fine example of such conical hills occurs near Kimble, and stands in front of Long Down. "The combe forks at the base of the hill, and the two branches have already cut their channels in such a way as to meet again. In time the gradual dissolving away of the chalk along these channels may make the hill still more detached, like the one further off on the right." (Whitaker, *op. cit.* p. 489.)

Chequers Park, which includes part of the escarpment range above Great and Little Kimble, is one of the most beautiful demesnes in England, with its combes and wooded slopes, its "Velvet Lawn" and "Cymbeline's Mount." In 1889 I wrote of this as follows:—"The escarpment is very steep, and is trenched by some magnificent combes, several of which remain in their natural state, the slopes being partly covered with short green turf, partly with thickets of box, and partly with copses of trees, the whole forming a piece of scenery unsurpassed by that of any other place along the escarpment." (*Op. cit.* p. 489.) The floors of the combes form even grassy walks, and it is one of these that is known as Velvet Lawn. Cymbeline's Mount is a small conical hill, apparently crowned by a tumulus, so that it is partly natural and partly artificial.

Hertfordshire, Cambridgeshire, and Suffolk.—Near Hitchin the tract of country occupied by the outcrop of the Lower and Middle Chalk widens out considerably, and instead of there being one dominant escarpment, with one or two terraces in its descent, it separates into three definite escarpment-ridges, each with its steeper frontal slope, and its more gently-inclined backward slopes, the outer ridge corresponding with the outcrop of the Totternhoe Stone, the second one with that of the Melbourn Rock, and the third with that of the Chalk Rock, this last being almost always the boldest and the highest. In this way the outcrop of beds, which in the South of England are often comprised within a single slope not more than a quarter of a mile broad, is spread out over a tract of country which is often from five to six miles in width.

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* Quoted from the "Geology of London," Mem. Geol. Survey p. 488 (1889).

These features continue to present themselves as far as the neighbourhood of Newmarket, but between that town and Bury St. Edmunds the upper escarpment gradually declines in height and ceases to exist. This may be partly owing to the dying out of the hard Chalk Rock, which seems to disappear simultaneously, but I think it most probable that this escarpment was originally continued through the northern part of Suffolk and into Norfolk, though perhaps its features were always less pronounced than they were in more southern counties. If this was the case, its ridge has been completely planed down by the ice of the Glacial Period, and the whole region has been covered with a mantle of Glacial Drift, through which the Chalk now peeps out in irregular patches.

Lincolnshire and Yorkshire.—In Lincolnshire the escarpment of the Chalk once more becomes a conspicuous feature, but it differs in some respects from those which have been described above. Thus the thickness of chalk which crops out below its summit ridge is small (less than 100 feet), and the greater part of the frontal slope consists either of Lower Cretaceous beds or of Jurassic clays, according as the Chalk oversteps the one series on to the other. Thus the escarpment of the Chalk itself is only the upper part of the slope which forms the descent from the Wolds. Again, there is seldom any second slope or rise from the outcrop of the Lower Chalk to that of the Chalk with flints, and as a rule the escarpment-ridge is the dominant feature, forming a continuous watershed, and separating the valleys of the Wolds from those of the country to the westward.

There are, however, two breaks in the continuity of the escarpment, one near the southern end, where the valley of the Calceby beck cuts completely through the Wolds, running from west to east; the other north of Donnington, where it is deeply indented by the head waters of streams which unite to form the river Bain. Beyond this point, and all through North Lincolnshire, there is a continuous escarpment-ridge, except that at Melton Ross there is a well-marked depression or pass, which appears to be a truncated valley. Everywhere the frontal edge of the escarpment is a more out beyond the recesses in which these high-level valleys now terminate.

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In Yorkshire there is once more a change, for along the western border of the Yorkshire Wolds the Chalk can hardly be said to form an escarpment. There is no regular slope rising steeply from the Jurassic plain into a continuous dominant ridge; on the contrary, in the southern part of the area and as far north as Huggate, the watershed is an irregular line running through the Wolds at some distance from their western border, and the western versant is furrowed by deep valleys, which drain into the river Derwent. Consequently, when viewed from the west the Wolds have the appearance of an undulating range of hills, and a transverse section generally shows first a slope formed by the Lower Chalk, and further east a longer one formed by the Chalk with flints (see Fig. 67).

It is only along the northern border from Knapton eastward that there is a continuous escarpment-ridge, and even this is interrupted by the Hunmanby fault, which carries the Chalk on one side below the alluvium of the Vale of Pickering. The ridge, however, is continued eastward from Hunmanby till it is cut off in Speeton cliffs.

Chalk Uplands.

Behind every Chalk escarpment there is a tract of greater or less width, which may be called an "upland," inasmuch as it consists of high round-backed ridges of chalk, branching out from the summit of the main escarpment; each such ridge dividing into shorter ridges, divided from each other by deep combes or valleys.

These Chalk uplands, when bare of surface deposits, form open "downs," covered with short turf but without trees, though on their slopes scattered bushes of box and juniper are sometimes to be seen, and sometimes a few gnarled old thorn bushes. When, however, the ridges are capped by a surface deposit of brickearth or of clay-with-flints, they bear (or formerly bore) extensive woods, sometimes of small oaks and thorns, but more frequently of fine beech trees. Of such beech woods good examples are still to be seen on the Chiltern Hills and on Cranborne Chase, but even there they have been much reduced during the past century, large tracts having been enclosed, deforested, and converted into arable land.

The scenery of such Chalk uplands is probably familiar to most people who have lived in the south or east of England, and it has been described by several popular writers, notably by Charles Kingsley in his "Yeast," and by R. D. Blackmore in "Alice Lorraine."

But besides such uplands as lie behind the ranges of the North and South Downs, and that of the Chiltern Hills, there are some

Chalk districts of larger size which merit some special description; these are the Hampshire Downs, Salisbury Plain, Cranborne Chase, Marlborough Downs, and the Wolds of Lincolnshire and Yorkshire.

The Hampshire Downs.—The chalk region of Hampshire forms, with Salisbury Plain, the largest tract of chalk-land in the whole country. It occupies about half the surface area of Hampshire, occupying all that part of the county which lies to the west of the Weald. The hills which form its eastern border are often called the Alton Hills; they rise above the escarpment of the Lower Chalk, and form a very irregular second escarpment, rising in places to more than 700 feet. To the northward the ground gradually rises into another range of hills, which pass round the southern border of the Vale of Kingsclere, and the Vale of Shalbourn, and two of their summits rise to over 900 feet. In the south there is also some high ground, between Meon and the valley of the Itchen, forming a continuation of the South Downs.

These hill-ranges are, however, only the highest parts of a wide tract of undulating country which may well be called the Hampshire Uplands, for there are few parts where the chalk ridges do not rise to 500 feet above the sea. It consists, in fact, of a succession of broad-rolling downs intersected by a branching network of valleys. Between Odiham and Bishop's Waltham it has a width of twenty-three miles from north to south, and in the north-west of the county its width is about twenty-one miles. A fine view of the western part of these uplands may be obtained from any of the hill-tops between Highclere and Inkpen on the northern border, and the following description of this view is from the pen of the late Mr. H. W. Bristow:—

"From these lofty heights the eye commands, on a clear day, a view over a wide extent of beautiful scenery in all directions: looking towards the south the eye ranges over a broad and undulating landscape, composed for the most part of brown, turf-covered hills, with bold, rounded sides, and deep waterless valleys; both, as a general rule, bare of trees, and either in a state of nature, or only under cultivation here and there. Such is the general aspect of the [nearer portion], but stretching away into the distance is the more gently undulating tract of the Upper Chalk, whose valleys, well watered by streams and rivers and adorned with trees, give rise to scenery of a [different] kind."

The population of the district is scanty, and such towns and villages as exist are ranged along the courses of the streams. The presence of these streams is due to the high general elevation of the region and the consequent high level to which the subterranean plane of saturation (or water-level) rises in the central parts. The main drainage of the upland is carried off by the

Rivers Test and Itchen, which flow southward. These watered valleys are of the type which has been well described by Kingsley:— "Of all the species of lovely scenery which England holds, none, perhaps, is more exquisite than the banks of the chalk rivers; the perfect limpidity of the water, the gay and luxuriant vegetation of the banks and ditches, the masses of noble wood embosoming the villages, the unique beauty of the water-meadows—living sheets of emerald and silver, tinkling and sparkling, cool under the fiercest sun, brilliant under the blackest clouds."

Salisbury Plain is the western continuation of the Hampshire Uplands and the description above given is equally applicable to this district, which is not truly a plain but a wide expanse of undulating country; its rounded ridges rise one beyond another, hiding the intervening vales, but it is seldom that one overtops its neighbour, so that those in the distance seem to form parts of a nearly level plain.

Salisbury Plain is bounded on the north by the Vale of Pewsey and by the westward continuation of its southern escarpment to Westbury; on the south-west it is limited by the valley of the Wily, and on the south by the Avon valley, near Salisbury. It is drained by one river (the Avon) and three bournes, which are only watercourses during the winter months and in wet seasons; all of them run from north to south.

The extreme length of the plateau from the eastern border of Hampshire to the hills above Warminster is about twenty-five miles, and its width across the centre from Wilton to Wivelsford Hill is fifteen miles. If Salisbury Plain were reduced to one level by paring off the ridges to fill up the valleys, its surface would still probably be about 500 feet above the sea, so that it is truly an upland region.

The following general description of the chalk lands of Wiltshire, applicable both to Salisbury Plain and to Marlborough Downs, is quoted from the Rev. J. Sowerby's account of its topography in the Rev. T. A. Preston's volume on the "Flowering Plants of Wilts" * :—"The great characteristic of the chalk plateau is its vast extent of grass-land, where sheep are extensively pastured. This space is more broken up each year for cultivation, but often exhibits great tracts of grass with only occasional patches of furze. . . . The Upper Chalk hills were once, it is probable, covered with extensive copses, chiefly thorns: remains of these still occur here and there, and individual trees of great size, some yet extant, others only traditional, attest the former existence of a primeval wood. Monotonous as the surface of the downs may seem to be, the changes that present themselves are often singularly picturesque and varied. After passing, it may be for hours, over the gently-sloping grass-plains—all blue above, all green below—the traveller suddenly sees below him a village embosomed in woods, with its picturesque church tower surrounded by fertile and well-tilled land."

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* Published by the Wiltshire Arch. and Nat. Hist. Society in 1888.

The Dorsetshire Downs.—Another large area of Chalk-upland commences in the extreme south of Wiltshire (Cranborne Chase), and stretches southward through the northern part of Dorsetshire. On the north it is limited by the scarped range of hills which overlooks the Vale of Broad Chalke, and which consists of Lower, Middle, and Upper Chalk; on the west its border is the Main Chalk escarpment, and on the south-west there is the valley of the Stour from Blandford to Wimborne, but this only separates the tract above indicated from the slightly narrower tract of upland which forms the northern lip of the Dorchester basin.

The descriptions already given of the Hampshire Downs and Salisbury Plain will apply almost as well to the Dorsetshire uplands, except that the summits of the downs are often somewhat broader and flatter, and that much more of the surface is covered by woods. Cranborne Chase was originally all woodland, and though some clearings have been made in it of late years, much of it is still wooded, though chiefly by small trees such as thorns, hazels, and hollies. On the west also, south of Ashmore, there are some fair-sized woods, but farther south there are open downs covered only by grass, furze, and bracken, while the valleys are all cultivated.

The general slope of the district is to the south-east, in which direction the chalk eventually passes beneath the outcrop of the Eocene beds. The average width of the chalk land is about ten miles, and it is drained by two small streams—the Tarrant Water and the Allen—the upper parts of which run south-east, but are afterwards deflected to join the Stour.

The other Chalk-uplands in Dorsetshire, to the north and west of Dorchester, exhibit the usual features of such country, and do not require any special description.

The Yorkshire Wolds.—In the more northern counties the only large area of Chalk-upland is that of the Yorkshire Wolds. Those of Lincolnshire form a long strip of chalk-land, but are nowhere of any great width, varying only from four to six miles across. The Yorkshire Wolds are equally narrow in their southern part, but broaden out northward, and as they curve round the town of Driffield their width becomes as much as ten or twelve miles.

Some of their features have already been described (see p. 414), and it has been mentioned that from the Humber to Huggate Wold (a distance of about twenty-three miles) there is no escarpment ridge, but a watershed which follows a more or less medial line between the western and eastern borders of the Wold country. Towards the north-west this watershed rises in some places to a height of 700 feet, while the Lower Chalk on the outer margin of the Wolds reaches little more than 600 feet.

It results from this arrangement that the valleys of these Wolds do not all trend eastward, as they do in Lincolnshire, but form two separate and divergent systems; the one set running westward, and cutting through the outcrop-slope to drain into the River Derwent; the other set opening eastward into the flat of Holderness. Even in the northern part of the Wolds, where there is an escarpment-ridge, the valley system is very irregular, most of the smaller combes opening into the long valley of the Gipsey Race, which runs from west to east or parallel to the general strike of the beds.

There is only one valley which runs across the whole breadth of the Wolds; this has its highest branches among the hills east of Acklam, and has a length in a winding course of more than fifteen miles before reaching Driffield. Nearly all the valleys are of the waterless type usual in chalk-uplands, the only one occupied by a permanent stream being that of the Gipsey Race, above mentioned, and this often called the "Great Valley of the Wolds."

The Valleys of Chalk Districts.

The valleys which traverse the Chalk uplands may be divided into two classes—(1) the transverse valleys which breach the escarpments and are occupied by rivers rising outside the Chalk area; (2) the irregular branching system of valleys which commence inside the escarpment and seldom carry permanent streams.

With the great transverse valleys, such as that of the Thames, or those of the Arun and the Adur in Sussex, we are not concerned in this memoir, for they form part of the larger river-system of the country; and our attention is claimed by the valleys which lie wholly within the Chalk areas.

If anyone climbs the frontal slope of a Chalk-escarpment, say that of the North Downs or of Salisbury Plain, he will find on reaching the top that he does not stand on a broad plateau as he might have expected, but on a comparatively narrow "ridgeway," which is only flat for the width of a few hundred yards, and then curves down into a combe or is continued out into a long and equally narrow round-backed ridge between two combes or dry valleys. The panorama before him is in fact one of an intricate series of alternating ridges and valleys, the ridges ending in beautifully-rounded curves and the valleys opening one into another till their connection is lost in the distance. Fig. 73 represents an excellent case of a single series or group of small valleys carved out of a corner of Salisbury Plain.

If the explorer descends into one of these convergent combes he will not in ordinary seasons see any sign of water, and if he examines the floor of the larger valley into which the combe conducts him, he will notice in many cases that it is uneven, undulating slightly in a way that it would not do if it was ever occupied by continually

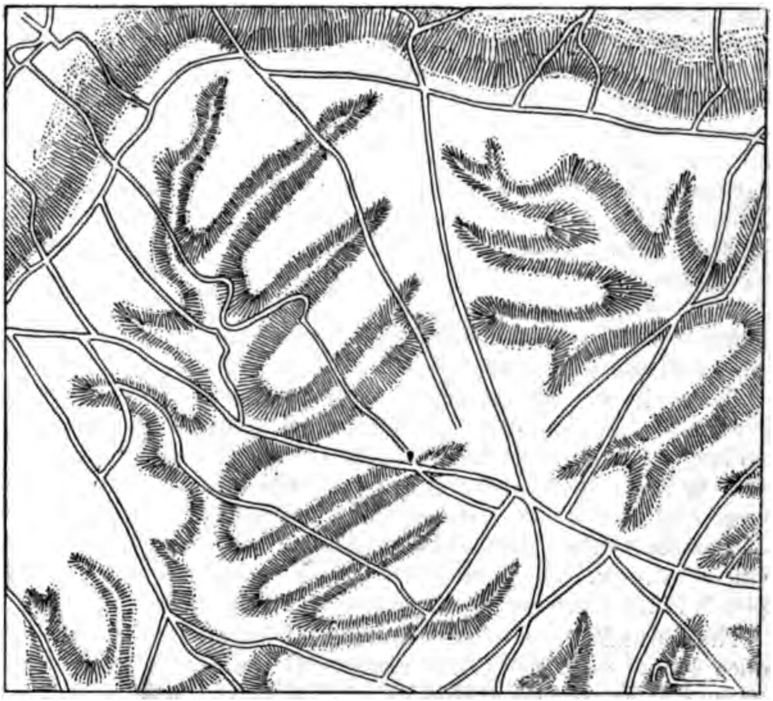

Fig. 73.—Sketch Map of a Group of Valleys on Salisbury Plain, South of Urchfont and Cherrington.

Copied from the old Ordnance map (Sh. 14). Scale one inch to a mile.

running water, even for a few weeks in the year. Possibly, however, after he has walked for a mile or two he may come to a spot in the valley-way where a curious cup-shaped hollow presents itself, and beyond which there is a distinct watercourse. In ordinary summers this watercourse will be dry, but in wet seasons and perhaps during every winter it will be occupied by running water, which rises as a spring from the hole or hollow aforesaid. Such occasional or periodical streams are generally called bournes or winterbournes, but in Sussex are known as *lavants*.

The dry valleys which ramify into the heart of the Chalk-uplands (as shown in Fig. 73) have steeply-sloping sides, often steeper than the slope of the escarpment itself, they are deep, and the whole district presents the aspect of a country which has once been full of running brooks and streams, and out of which a deeply cut system of drainage has been developed by such agencies. The existence of such valleys in districts which at the present time are practically waterless has struck many observers as remarkable and as a fact demanding explanation.

The dryness of chalk-uplands is not due to any lack of rain, for of course more rain falls upon them than on the inland plains, but chalk is such an absorbent rock that the rain which falls upon it soaks into the soil very quickly, and the little rills that do run down the valley slopes after rain disappear at the bottom before they can gather into a volume of running water. Only twice in my own experience have I seen a dry chalk-valley converted temporarily into a river. One occasion was in the summer of 1875, after three days' rain, when all the valleys which radiate from the Gog-Magog Hills near Cambridge became watercourses; the other time was in July, 1883, at Rothwell, in Lincolnshire, when the roadway along the valley became a watercourse, and part of it, for a distance of 80 yards, was covered with fine chalk-gravel washed down from the fields above, and other parts of the roadways were torn up into holes and runnels.

The rarity of such occasions makes it probable that the valley system of the chalk-uplands was formed under conditions which no longer exist, and we have therefore to consider what conditions may or must have existed in the past which would facilitate the erosion of valleys out of the chalk. Several such conditions have been indicated, and three of these can certainly be recognised as efficient causes, though one of them may have operated more completely in the more northern areas than in the southern.

These conditions are—(1) the cover of impervious clays which once spread over the Chalk areas; (2) the frozen state of the ground during the Glacial period; (3) the probable larger rainfall over the British area when the Glacial period was passing away. The last might not be very effective by itself, but in conjunction with either of the other two a greater rainfall would certainly cause more rapid erosion of valleys.

The second is doubtless to be regarded as one of the final causes which led to the deepening of the valleys and especially to the formation of those deeply-incised combes which occur in such close proximity to the escarpment ridges. Mr. Clement Reid was the first to indicate the effectiveness of this cause, especially in the area of the South Downs,* and the following is quoted from his paper on the subject. After referring to a time when the ground must have been frozen into a solid mass to a considerable depth as it is now in Siberia and parts of Canada, he remarks:—"This would modify the entire system of drainage of the country in a way which I do not think has been realised. All rocks would be equally and entirely impervious to water, and all springs would fail; while these conditions lasted any rain falling in the summer would be unable to penetrate more than a few inches. Instead of sinking into the chalk or other pervious rock, and being slowly given out in springs, the whole rainfall would immediately run off any steep slopes like those of the Downs and form violent and transitory mountain torrents . . . . Each of these floods would have an enormous scouring and transporting power . . . . This I believe was the origin of our steep-sided combes and of the Coombe Rock.

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* Quart. Journ. Geol. Soc., Vol. xliii. p. 364 (1887).

It may be added that even when the climate was so far ameliorated that the ground no longer remained frozen through the summer, such action would still go on in the spring of the year, and Dr. Hinde stated (Loc. cit., p. 373) that in Canada, " where the ground is solidly frozen to a certain depth each winter, a greater amount of denudation is effected in twenty-four hours, at the sudden break-up of the frost in spring, than takes place during the whole of the rest of the year."

But while these conditions help us greatly in understanding the formation of the deep coombes and short valleys in the higher parts of the Downs, we must remember that this cause can only have operated during the period of Glacial cold, and that we have very good reasons for believing that the main valley system of the Chalk areas was established long before the Glacial Period began. The present valleys are only more deeply incised portions of a more ancient drainage system.

We come, therefore, to the consideration of " clay-covers," and there are three different clays which have at one time or another served as *covers* on different parts of the Chalk area ; these are the clays of the Woolwich and Reading Beds, the London Clay and the Glacial Boulder-clays. The consequences attributable to the former existence of a mantle of Boulder-clay spread over a chalk country were, I believe, first pointed out by Mr. Penning and myself in 1881* ; and were more particularly described by me in 1887.† Although this refers to a cover of Boulder-clay, the process of valley making would be similar in the case of any other clay-cover, and so the description of it given in the latter Memoir may be quoted here :—

" It is tolerably certain, therefore, that the greater portion of the Chalk area was covered with a mantle of Boulder-clay, which invested hill and dale alike in one continuous sheet . . . . Such being the case, it is clear that the rain which fell on the surface would not soak into the Chalk, as it does now, but would course freely over the land ; the whole rainfall would consequently be made available for erosive purposes, and rain would be collected into rapid streams in situations where no water ever runs at the present time.

" The course taken by these brooks and torrents would be determined by the irregularities in the surface of the Boulder-clay, and their channels, once formed, would be continually deepened until they reached the surface of the underlying Chalk. This [rock] also would be deeply trenched as long as so much of the clay-mantle remained as sufficed to shed the greater portion of the rainfall into these channels. It is probable, however, that this clay-mantle was very thin on the higher ground, and as it was gradually removed by the general detrition of the surface a larger and larger area of bare chalk would be exposed, and more and more of the rainfall would be exposed."

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* Geology of the Neighbourhood of Cambridge, p. 122, Mem. Geol. Survey (1881).

† Geology of East Lincolnshire, p. 126, Mem. Geol. Survey (1881).

In Lincolnshire, however, as in other parts of England, there is clear evidence that most of the valleys in the Chalk area are of pre-Glacial date, and as it is only in certain places that one of the modern valleys diverges from the course of the ancient valley, it would seem that the Boulder-clay to a large extent draped the features of the pre-Glacial surface, and that the post-Glacial streams ran for the most part along the depressions which marked the course of the ancient valleys. Even in the north, therefore, we have still to look much further back in geological time for the initiation of the great system of valleys which has since become so deeply incised on the higher parts of the Chalk Wolds and Uplands.

To realise the conditions under which these valleys were excavated out of the Chalk, we must briefly glance at what is known with respect to the western extension of the Eocene Beds and the relative positions occupied by Cretaceous and Eocene strata when the land rose from the Eocene submergence.

In the eastern part of England there can be no doubt that both the Woolwich and Reading Beds and the London Clay spread far to the westward and northward beyond their present limits, and that they covered all the existing tracts of Chalk in East Anglia; further, it is equally certain that the Chalk extended far beyond its present escarpment, and was continued *beneath the Eocenes* over a large part of central England. But judging from the rapid thinning out of the Lower Eocenes in Wiltshire, where at Chisbury near Marlborough the Bagshot Sand comes to within 25 or 30 feet of the Chalk;* and from the complete overlap of the London Clay by the Bagshot Beds in Dorset, we may infer that over the western part of England these gravels and sands came to rest directly on the Chalk. There is, moreover, evidence that they even passed completely across the Chalk, so as to be on the surface of the Upper Greensand; at any rate, this was the case in some places.

It is evident, therefore, that when the western country came under the influence of subaerial agencies during Oligocene and Miocene times, river courses must have been established on the surface of the widespread Bagshot Sands, and I think the valley system then formed must be regarded as the parent of the existing system, although, of course, it has been largely modified during the lapse of the intervening time.

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* See W. Whitaker in Mem. Geol. Survey, Vol. iv. p. 177 (1872).

† See C Reid "On the Eocene Deposits of Dorset," Quart. Journ. Geol. Soc., Vol. lii. p. 490 (1896), and Geology of Dorchester, p. 28, Mem. Geol. Survey, (1899).

During the Miocene epoch, when the land probably attained a high elevation, we may suppose that the valleys which had been commenced on the surface of the Bagshot Sands became more deeply incised, and that, as these sands were gradually worn away and removed from the higher parts of the land, the drainage system would be impressed upon and transferred to the underlying strata, whatever they might be, whether Selbornian, Chalk, or London Clay.

Let us consider a single area as an example, and let us take that which now presents the largest expanse of bare Chalk in the country—the uplands of Hampshire and Wilts. We may safely assume that there was a period in the history of this tract when the Bagshot Beds were reduced to outliers, and when the greater part of its surface was formed of London Clay (underlain by Reading Beds), and when the Chalk was only exposed in places along the lines of what are still the principal river-valleys, those of the Itchen, the Test, the Bourn, and the Avon.

In early Pliocene time there was a decided subsidence of eastern England, and the Pliocene sea invaded not only Suffolk and Essex, but also the greater part of Kent (Lenham Beds). This subsidence must have imparted an easterly tilt to the Eocenes, but it does not seem to have affected the courses of the principal rivers, at any rate, in Southern England. This subsidence was followed by local upheaval along the anticline of the Wealden area, or more correctly, perhaps, along a part of that anticlinal complex; but as this upheaval did not prevent the streams above mentioned from continuing to hold their courses across the Wiltshire and Hampshire uplands, either the general uplift must have been so gradual that they were able to keep their channels open, or, what is more likely, the flexure only added to the height of that tract, which was already the watershed, namely, the northern line of anticlinals from the Vale of Pewsey, by Shalbourn and Kingsclere to the Hogsback.

My view regarding the valley systems of the Hampshire Downs and of Salisbury Plain is, then, that they were originally impressed upon the Chalk by having been cut through a cover of Eocene clays, that they are in fact systems of drainage which have been transferred from one formation to another. Just as in Lincolnshire the post-Glacial valley erosion was continued as long as a sufficient cover of Boulder clay remained, so in the southern area the streams running over and off the Eocene clays would continue to extend and deepen the valleys as long as any considerable amount of such clays remained on the intervening ridges and plateaus.

Here, too, it should be mentioned that in the opinion of Mr. C. Reid and myself, the material of the "clay-with-flints," which is found as a capping on so many of the higher chalk ridges, has been derived to a far larger extent from the Eocene clays than from the minute quantity of insoluble matter existing in the Chalk. If this is the case, then the quantity of "clay with flints" has not increased *pari passu* with the general detrition of the Chalk, but has been gradually reduced to the condition of outliers from a state of much wider extension.

Thus, as the Eocenes were being gradually removed from the central Chalk area by the action of rain and rivers, we imagine that their residual material (now incorporated in the clay with flints) would remain in great force on the plateaux, and would still serve as a clay-capping from which rain would be shed. Thus it seems to me that the existent waterless condition of the Chalk uplands was only brought about by the slow and gradual removal of the clay-with-flints and did not supervene till the area of uncovered chalk was much larger than the area still covered by that clay.

Among the final stages of erosion the frozen condition of the ground during a part of the Glacial Period, and the consequent frequency of floods, as described by Mr. Reid, was no doubt largely contributive to the deep excavation of the terminal valleys in the Chalk districts. We must remember, too, that the minor movements of elevation and depression would each accelerate or retard erosion, elevation accelerating and depression retarding it, and would thus affect the process of valley making.

If, as seems probable, the "Coombe Rock" of Sussex and the "Head" of Cornish coasts were formed in a period which followed the time of depression in which the materials of the raised beaches were deposited, then the movement of upheaval must be accredited with its share in assisting the final process of valley erosion; while the succeeding movement of subsidence (alluvial levels) will account for the stoppage of active erosion, and the initiation of the present stationary state of things.

CHAPTER XXVII.

WATER SUPPLY FROM THE CHALK.

1. SPRINGS.

The phenomena of springs involve the consideration of many local conditions, and are not always of a simple nature; but when the Chalk is regarded as a source of water supply it is desirable in the first place to study the springs which issue from it and their relations to the local water levels. It will be found that in some localities the Chalk behaves as if it were composed of one uniformly permeable kind of material, while in other places the springs break out at certain geological horizons where layers or beds o' less permeable material appear to be the local causes of outflow.

The location of springs within the area of the Chalk may, I think, be referred to one or other of the following causes:—

1. Simple overflow of underground water at points where the level of the ground falls below the internal level of saturation.
2. Outflow caused by the outcrop of a less permeable stratum.
3. Outflow at a higher lèvel in consequence of the displacement of the beds by a fault.

The first case is illustrated by Fig. 148, which will also serve to explain what is meant by the term internal level of saturation. The figure may be regarded as a section through some part of the Chalk escarpment, which generally presents the aspect of a watershed ridge with a steep slope on the outer side (towards which the beds rise), and more gentle slopes, channelled by deep valleys, on the other or inner side. The water falling on the ridge and on its slopes is disposed of in three ways, a small part runs off the surface, a large part is evaporated or absorbed by plants, and a smaller part sinks into the ground and percolates through the chalk.

Recent experiments have shown that the amount of rain which runs off a bare chalk surface is so small as to be negligible, but there is some difference of opinion as to the proportional amounts that are retained and evaporated. They vary much in different years; thus Mr. J. Hopkinson found that out of a rainfall of 26 inches the amount evaporated was on the average 74 per cent., the remainder (26 per cent.) being absorbed, but that sometimes the proportion was as 63 to 37. Other observers believe that from 40 to 46 per cent. of the rainfall generally percolates downward from surfaces of bare chalk.

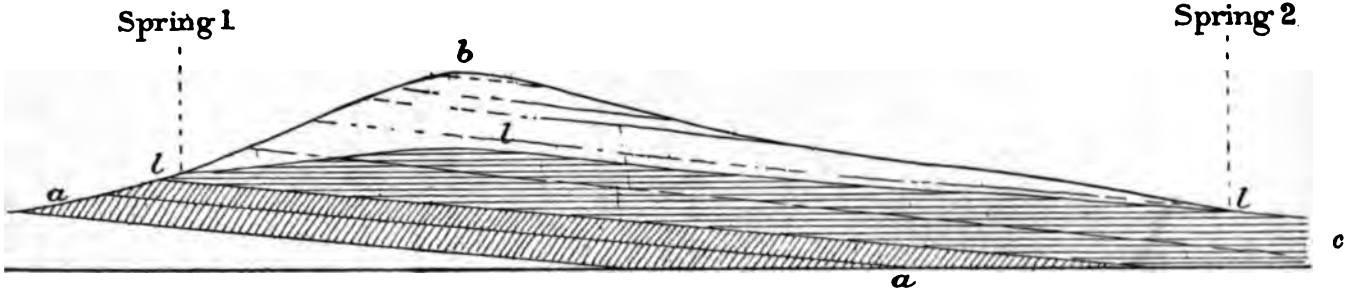

Fig. 74.—Diagram to illustrate Springs and Level of Saturation.

a a. Impervious part of chalk.
b c. Pervious part of chalk.
l l. Level of saturation.

The water which sinks into the ground percolates downward through the chalk till it is arrested by some bed which is nearly impervious; in the diagram it is supposed to have sunk till it reached the marly chalk near the base of the formation. Being thus prevented from sinking lower it accumulates in the lower parts of the chalk, which thus become saturated with water up to a certain limit or level, and this limit is called the level or plane of saturation (*l*, *l*, in Fig. 148).

The water thus imprisoned, naturally tends to escape at points where the level of the ground falls below the level of saturation. Hence there are generally springs along a certain level (Spring 1) on the front of the escarpment and others at a rather lower level (Spring 2) in the valleys which trench the other slope. The level of saturation is not represented by a straight line between these two points, because the water passing downwards and outward through the mass of the chalk cannot flow freely as it would on the surface, but is retarded by friction and capillary attraction Thus the water is held up as it were beneath those tracts where the surface of the ground is highest, and where the distance it has to pass through is greatest. Consequently, the level of saturation rises under the escarpment ridge and falls towards the spring heads; in a minor degree it rises under every ridge or hill so that regarded over a large area the level of saturation is an undulating plain.

Let us next consider the cases in which springs appear to be thrown out by definite beds in the chalk. There are four such horizons which serve as special water-carriers, each of them being underlain by a tough marl of greater or less thickness. These beds do not all occur in one district, but, taken in descending order, are:—

1. The Melbourn Rock.
2. The Totternhoe Stone.
3. The Marl-rock of Oxfordshire and Bucks.
4. The marl-band (No. 5 of Price) near Folkestone.

Some of the localities where springs issue from these beds will be mentioned hereafter, but it concerns us first to ask under what circumstances they act as water-carriers, and why some of them do not always intercept the water percolating downward through the chalk.

I think the main condition of their so acting is that the outcrop of the bed shall not be far above the usual local level of saturation. Where this is the case the underlying marl never gets very dry and forms a continuous impervious stratum through which little water can make its way. But where the outcrop of the rock bed rises to a high relative level, both it and the underlying marl become desiccated in dry weather every year, they have consequently contracted and have become fissured, for such fissures once formed would never be closed again, but would rather tend to become widened in the course of time. This is certainly the case with the marl beds beneath the Melbourn Rock, which are often broken by fissures at and near their outcrop. In such circumstances the water sinking through the chalk and reaching the Belemnite marls is only held up for a certain distance, running over the marl till it finds a fissure, through which it passes and makes its way to a lower level.

As Mr. Whitaker has pointed out to me this view will explain the fact that the Melbourn Rock throws out a strong spring at Holywell, near Eastbourne, where it is only a few feet above high water mark, while a few miles inland the same bed, at a high level, is quite dry.

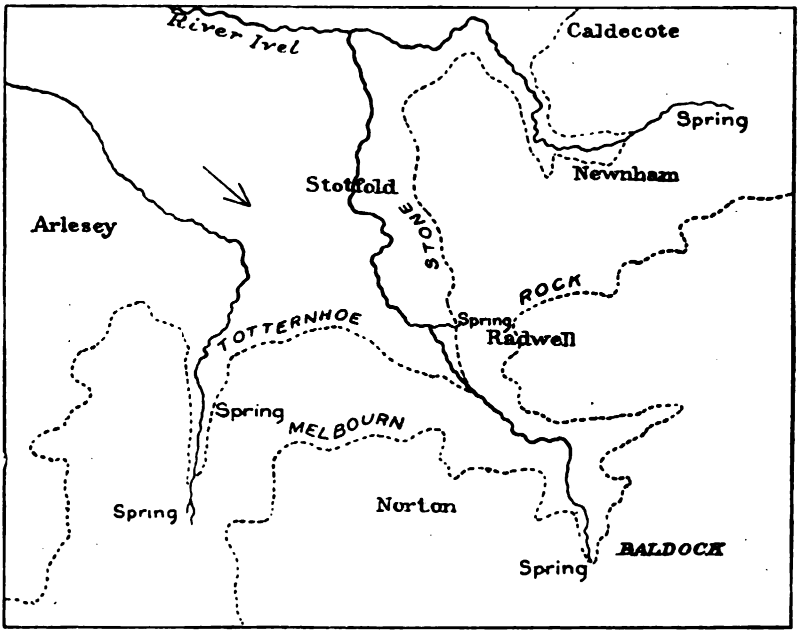

FIG. 75.—Map showing springs from two horizons (Totternhoe Stone and Melbourn Rock), near Baldock. (Sh. 46. N.E.)

In some districts where the dip is slight, and where the outcrops of the Melbourn Rock and Totternhoe Stone form subsidiary escarpments, springs are thrown out from both horizons, as in the country near Hitchin and Baldock. In this case the springs from the Melbourn Rock are fed partly by water flowing outward and westward from the main escarpment of the chalk, and partly by water flowing eastward along the plane of the rock from the more western ridges and outcrops; while the springs from the Totternhoe Stone must be fed almost entirely from the water falling on the tract lying between its outcrop and that of the Melbourn Rock.

There remains to be considered a third cause for the location of springs, that of displacement of the strata by a fault. Though not frequent, cases do occur where an impervious bed is brought upon one side of a fault, with the result that it raises the level of saturation and gives rise to a spring or springs where otherwise none would occur.

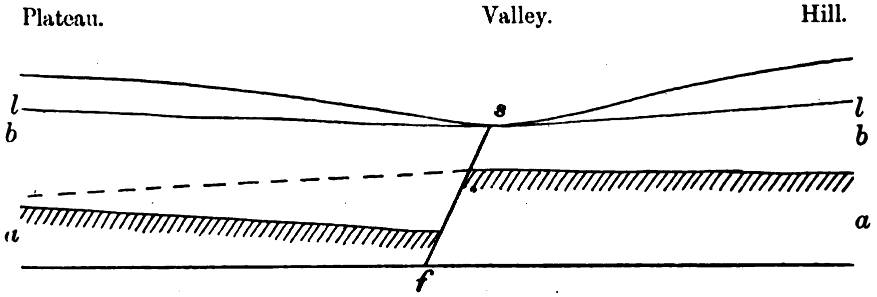

FIG. 76.—Diagram to explain how a Fault may give rise to a Spring.
a, *a*, impervious part of chalk. *l*, *l*, saturation level.
b, *b*, pervious part of chalk. *f*, *s*, fault.

The possibility of this is shown by the diagram Fig. 76, where the beds *a a* are supposed to be impervious, and *b b* are pervious, both being broken by the fault *f s*. If there had been no such fault, and the beds had continued in the direction of the dip from *a* to *f*, the level of saturation would have passed below the bottom of the valley (*v*), but the upthrow of the beds on the other side of the fault *f s* brings the impervious beds so near to the surface of the ground in this valley that the ordinary saturation level is raised to the position indicated by line *l s l*, and the result is the issue of water in a spring at some point near *s*. The effect of the fault is in fact to imprison a certain amount of water permanently in the angle of *a f s*, so that the saturation level is raised to the same position that it would occupy if the surface of the impervious bed were raised to the level of the broken line.

With respect to the conditions which determine the actual points of issue of springs along the front of an escarpment they are probably of several kinds ; sometimes they are slight undulations in the strata along the line of strike, and the springs issue in the troughs of these undulations, as for instance at Cherry Hinton near Cambridge; in other cases the point of issue may be determined by a fissure, the opening of the fissure at the surface offering a path of least resistance.

Springs issuing from the Chalk may be grouped in three classes according to their position with regard to the principal physical features of the country.

1. Springs outside the Chalk-escarpment.
2. Springs inside, but not far from, the Chalk escarpment.
3. Springs rising near the Eocene boundary.

The general conditions which cause the outflow of water in these different positions may be briefly described.

1. *Springs outside the Chalk-escarpment.*

By the word outside, in this connection, is meant that side which slopes towards the base of the formation, as contrasted with the inner side or that which slopes toward the newer beds occupying the interior of the Chalk basins. In this sense the springs which issue from the bases of the North and South Downs are outside springs, and their water flows outward into formations which are older than the chalk, although in many cases it ultimately passes into rivers which carry it back through the Chalk-escarpments.

The springs which issue from the chalk along the foot of the Chiltern Hills, and along other parts of the main escarpment of the chalk, come of course under the same category, and there is no need to give any special description of them. They are as a rule perennial springs, though in specially dry seasons the volume of the issuing water becomes small and some of them occasionally go dry. The seasonal variations in their flow are a matter for local study.

Where the tract below the escarpment is narrow there is seldom more than one set of springs, but where the space between the boundary of the Lower Chalk and the top of the escarpment becomes wider, as in Cambridgeshire, Suffolk, and Norfolk, more water is thrown out and springs issue from two or more different horizons.

2. *Springs inside the Chalk Escarpment.*

The springs which issue on the inner side of a Chalk-escarpment are such as would occur in the position S^2 in Fig. 76, and at other points still lower down the slope of valleys that run toward the interior of the Chalk basins.

Such springs are seldom perennial, and the position or point of outflow is liable to great variation according to the season of the year and according to the dryness or wetness of the season.

Hitherto we have spoken of the level of saturation as if it was always maintained at the same or nearly the same level, but this is by no means the case. There is a normal summer level and a normal winter level, and these again are only maintained if the rainfall of the preceding six months has been about the usual or average amount. If there has been a deficiency of rain the springs which are nearest to the escarpment dry up, because the plane of saturation sinks below the level at which they occur. On the other hand, if there has been an excess of rainfall, springs often break out still higher up the valleys beyond the position of what is usually the highest spring.

Springs which only flow at certain times of the year, or only after a prolonged spell of rainy weather, form temporary streams, which are known as *bournes, nailbournes, winterbournes, woe-bournes, levants,* and *gypsies* in different parts of the country. Some of them break out every year at the same spot, and the phenomenon is known to the countryside as the breaking-out of the bourne: these may be called regular bournes, and are generally *winterbournes.* Others only come into existence after a season of great and prolonged rainfall, and these may be termed "occasional" bournes. In some localities they are regarded with superstitious terror, and have been called *woo* or *woe-* bournes under the idea that they only appeared when some disaster was about to happen.*

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He refers to the experiments made by Mr. Ch. Greaves between the years 1852 and 1882 on the proportion of percolation to rainfall, and finds that the rising of the bourne really coincides with those years in which Mr. Greaves found the amount absorbed by percolation to be unusually great in the second half of the year.* The observations conducted at Lea Bridge showed the total annual amount of percolation to vary from 4 to 12½ inches, the amount in the latter half of the year varying from less than an inch to over 6 inches. Thus in 1860 the amount of water making its way downwards between June and December (inclusive) was 5·199 inches, in 1865 it was 5·699 inches, and in 1872 it was 6·100. This conclusion is confirmed by a comparison with the year 1866, which was actually wetter than 1865, but most of the rain fell in the first half of the year, and the amount percolating through in the latter half was only 3·587 inches, and consequently there was no bourne in that year.

The account of the Caterham Valley bourne, above given, may be taken as illustrative of the phenomena of occasional bournes, but, as already stated, there are many bournes which break out every winter, and it is only in exceptionally dry seasons that they do not run.

The reason of the difference between the phenomena of occasional bournes and of winterbournes consists in the relative height of the valley-floors above the normal winter level of saturation. A section drawn by Mr. J. Lucas along the course of the Caterham bourne† shows that the points where the bourne breaks out are all well above the ordinary winter level of saturation, and that it is only when this is raised to an unusually high level that the bourne holes are brought below its plane. A winterbourne occurs where the valley-floor is nearer to the permanent level of saturation, so that the ordinary rainfall of autumn and winter is sufficient to raise the level of saturation above that of a certain part of the valley-floor.

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In Sussex a winterbourne rises in the valley east of Ashcombe, and flows through the Vale of Southover into the River Ouse at Lewes. The valley of its source is quite dry during summer and autumn, the bourne rising generally at the end of the year, and flowing through December, January, and February, and often lasting into March.

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3. *Springs at the junction of Chalk and Tertiaries.*

The issue of water from points on the line of junction beween the Chalk and the Eocenes depends primarily upon the angle at which the strata are inclined, and upon the physical features which are governed by, and vary in accordance with, the dip of the beds. Mr. Whitaker has given a clear explanation of the manner in which such springs arise,† accompanied by figures, which are reproduced in our Figs. 77 and 78. He points out that where the dip of the beds is high, the incoming of the Eocene classes according to their position with regard to the principal physical features of the country.

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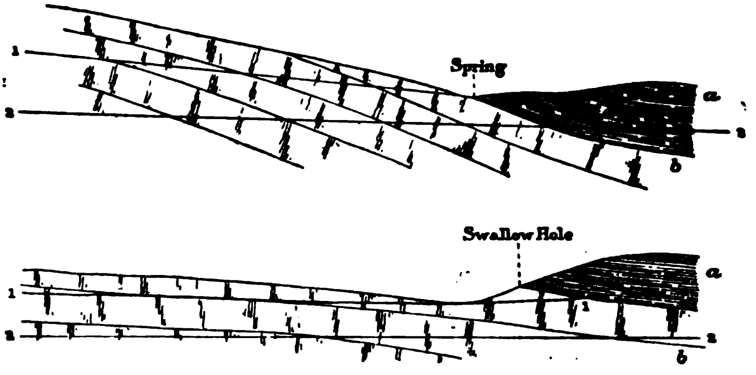
Reference to Fig. 77 shows that in the first case the water which is flowing and percolating through the chalk toward the Eocene beds must tend to saturate the whole mass of chalk which underlies those beds, and the saturation level is consequently kept so high that many points along the junction of the two formations are permanently below it; it follows, therefore, that water will issue at these points. This is the origin of many springs in Surrey, from Croydon westward.



Figs. 77 and 78.

a = Eocene Beds. *b* = Chalk.

1.1. Level of Saturation. 2.2. Sea-level.

When the disposition of the beds is similar to that shown in Fig. 78, the dip being low, no such springs occur, because the level of saturation is nearly always below that of the junction of the Chalk and Eocene, and it is very rarely that the bottom of a valley touches the saturation level. Such conditions are favourable to the formation of swallow holes at the boundary of the two formations, *i.e.*, of holes in which water flowing on the surface of the Tertiary beds is swallowed up and conveyed underground to the Chalk beneath the Tertiary basin.

Other clays besides those of the Eocenes may be so placed with regard to tracts of chalk that similar conditions are produced.

This is the case in East Lincolnshire and in the south-east of Yorkshire, where Boulder-clays are banked up against the Chalk in such a manner and to such a depth that the Chalk beneath them is saturated with the water which flows underground from the Wolds, and some of it is thrown out in springs at the junction of the Chalk and Drift. The following is quoted from the Survey memoir on East Lincolnshire (p. 136):—" As the depth of Boulder-clay at a few hundred yards distance from the boundary line is from 60 to 90 feet it is evident that this impervious mass obstructs the flow of the water which is percolating eastward through the Chalk and forces much of it to the surface. The result is that a number of perennial springs affording an excellent and abundant supply of water break out at those points along the line where the level of the ground is lowest, and generally where one of the dry valleys that trench the Wolds opens on to the Boulder-clay plain."

WATER FROM DEEP WELLS AND BORINGS IN THE CHALK.

It has been stated that the springs which issue from the Chalk wherever they are situated are only the overflow of the water which is permanently stored up in the more deep-seated parts of the formation. By far the larger quantity of the water which is absorbed by the exposed surfaces of chalk passes downward and inward below the Tertiary and Post-Tertiary beds which cover such large areas of the formation.

These deep-seated tracts of chalk form what may be termed underground reservoirs, in which a vast supply of good water is continually stored up, and these reservoirs have been tapped by hundreds of wells and borings, especially in the neighbourhood of London. Moreover, in consequence of the depth to which the Chalk is carried by the synclinal curvature of the London and Hampshire Basins, most of these borings are artesian in the sense that when the water is reached it rises to a high level in the boring and sometimes overflows. The subterranean areas of chalk are consequently very important and very easily utilised sources of water supply, and this is the case not only in the London and Hampshire Basins, but also in the more northern areas of Norfolk, Lincolnshire, and Yorkshire, the two latter of these really forming the western border of a third Tertiary Basin, the centre of which has been invaded by the sea.

It must not be imagined, however, that either the upper surface or the basal plane of the Chalk in these basins maintains anything like a regular continuous curve, increasing gradually from the margins of the basin to a trough of maximum depth. The subterranean stratigraphy of the Chalk is at present very imperfectly known, but the available information is sufficient to make it certain that no such regularity prevails in the Hampshire or the London Basin; on the contrary, the Chalk is broken by faults and disturbed by flexures which run in various directions, and sometimes form deep local troughs or ridges.

Mr. W. H. Dalton has made a special study of the subterranean surface of the Chalk in Essex, and has shown that in the southern and eastern parts of that county it is bent into an irregular system of minor basins and ridges which are often suddenly cut off by lines of faulting.* His paper is illustrated by a map of the county, in which these undulations and interruptions are indicated by contour-lines of depth below Ordnance datum-level. This map is reproduced in the useful "Report on the Water-supply of the County of Essex" by Dr. J. C. Thresh, which should be read by everyone who is interested in the subject.

Mr. W. Whitaker has pointed out that in regard to capacity as a water conductor, chalk holds a sort of intermediate position between a loose rock, such as a sand or soft sandstone, and a compact rock like an ordinary limestone; "for whilst a certain amount of water may travel slowly through the spaces between the particles, as, indeed, may be seen to be the case in wells and adits, where a general weeping occurs along the sides or walls, a greater quantity probably finds an underground channel along the planes of bedding along which there are sometimes slight openings, and which must always be planes of weakness. Still more, however, finds its way down and along other divisional surfaces which have been formed after the consolidation of the rock; these are the joint planes, formed perhaps by shrinkage, which are everywhere present [running] in various directions and more or less vertical, and sometimes causing slight openings or fissures that can be clearly seen.

"From this it follows as a rule that, to get a supply of water from the Chalk, some of these fissures must be cut. Now, when a boring is made the breadth of chalk can be measured by inches, and though by good luck a fissure may be cut and a good supply of water got from it, yet on the other hand it is equally (or perhaps much more) likely that this result may not happen; the boring is [then] condemned as a failure, and the water bearing power of the Chalk is put down as small.

"What then is the course that should be followed to get large supplies of water from the Chalk? Clearly a boring is not always to be depended on, and, therefore, the old plan of digging a well has to be resorted to, which, of course, increases the breadth of the work and with it the chance of cutting a water-yielding fissure. To get very large supplies, however, the object is to cut many of these fissures, in fact, to expose as great an amount of surface as possible, and to admit the inflow of water from as great an extent of chalk as can conveniently be got at. This, of course, must be done by lateral rather than by vertical extension, and the plan adopted is the driving of small horizontal tunnels (galleries or *adits*, as they are called) below the plane of saturation of the Chalk, and in such directions as to tap the greatest amount of water."*

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* "The Undulations of the Chalk in Essex," The Essex Naturalist, vol. v. p. 311.

Even the method of driving adits does not always succeed in obtaining an adequate supply of water, for the Chalk is not always fissured to the same extent, and is sometimes entirely without open fissures. It is probable that the existence or absence of fissures in deep-seated chalk depends mainly on the position of the subterranean flexures, for the joints and cracks will be more open along the anticlinal axes, while in the synclines the chalk will be close and compact, and generally without fissures. This is probably the reason why Richmond has failed to get an abundant water supply from the Chalk, notwithstanding the depth of the well and the construction of 3,460 yards of headings into the chalk, which however only yield 260,000 gallons a day. Reporting recently on this failure Mr. Mansergh writes, "All the information obtainable, and especially the experience of your own works points distinctly to the fact that the chalk underlying Richmond is very close and compact, containing few fissures or other channels by which water can pass freely, and that it very unlikely that you can ever expect to procure from this source all the water required for the growing needs of the Borough." (Contract Journal, Feb. 6, 1901).

Another instance where the chalk does not yield water freely, and where a deep synclinal trough is known to exist (see Mr. Dalton's map) is the neighbourhood of Chelmsford. In a report on the Springfield and the Great Baddow Waterworks (1899) Messrs. Thresh and Dewhirst discuss the probability of obtaining a good supply by boring down into the Chalk and remark that "in this portion of Essex the chalk appears to be very dense with few open fissures, and not to yield water freely."

There are, however, other planes along which water flows in the Chalk; thus in the Middle Chalk and in the lower part of the Upper Chalk thin layers of marl or marly clay occur, and are persistent over large areas; these must hold up a certain quantity of water where fissures are not frequent. Again, it is known that water often makes its way along the layers of flints in the Upper Chalk. This was specially noted in a boring at Thames Haven made in 1879. Here the Chalk was entered at a depth of 268 feet, and water rose to the level of the marshland; at 360 feet a water-bearing layer of flints was struck, and the water rose 11½ inches above the marsh-level. As the boring progressed other flint-layers were traversed, each increasing the supply until at 570 feet the water rose 19 inches above the marsh-level.* A boring made at Mitcham, in Surrey, in 1850 affords another good record of the same fact; it only penetrated 22 feet of chalk, but found "layers of flints every 3 feet and abundance of water in every layer."†

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* Geology of London, Vol. i. p. 510, Mem. Geol. Survey (1889).

It is worthy of note that water issuing from the Chalk, whether in springs or from deep wells and borings, varies but little in temperature all the year round, being always about 50 deg. Fahr., hence it seems fresh and cool in summer and almost warm in the winter, with the further consequence that chalk springs are rarely frozen up.

QUALITY OF WATERS OBTAINED FROM THE CHALK.

The water of springs issuing from the chalk is always clear brilliant, colourless, and palatable, and except in rare cases where it is polluted by the infiltration of organic matter from the neighbouring ground, it is good and wholesome water. It contains only minute traces of organic matter, but is always more or less hard, this hardness being mainly of the kind called *temporary*, that is, due to the presence of carbonate of lime and carbonate of magnesia in solution, which are easily and cheaply removed by the addition of slaked lime to the water.

The water obtained from wells sunk through the chalk, where it forms the surface soil or is covered only by permeable deposits, is of a similar character, always (when unpolluted) containing but a trace of organic matter, but always holding in solution a considerable amount of carbonate of lime.

When, however, water is obtained from deep borings carried through the London Clay and London Tertiaries into chalk saturated with water it is found to exhibit a great difference in character. The total amount of solid matter in solution is much greater, on the average twice as great; while the hardness is much less and is much more due to the presence of soda salts such as the carbonate and sulphate of soda; there is also generally a considerable quantity of common salt (sodium chloride) in solution. The amount of organic matter is usually rather larger but is still very small and the water obtained from such borings is generally clear, palatable and wholesome.

The existence of these differences in the character of chalk waters according to their source from beneath bare chalk or from below the London Clay, etc., was indicated in the Sixth Report of the Rivers Pollution Commission (1874), and was illustrated by several series of analyses of such waters. The following are the averages of the results of these analyses as given in that Report, the quantities being expressed in parts per 100,000:—

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* See Whitaker "Geology of London," p. 37, and Dr. Thresh "Report on the Water-supply of Essex," p. 26.

† Whitaker, *op. cit.*, p. 208.

—	Total Solids in Solution.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Total Combined Nitrogen.	Previous Sewage Contamination.	Chlorine.	Hardness.		
								Temporary.	Permanent.	Total hardness.
Average of 30 analyses of spring waters	29·84	·044	·010	·001	·392	3·511	2·45	18·1	5·5	23·6
Average of 38 analyses of deep well waters	37·45	·052	·019	·002	·631	5·806	2·53	21·5	6·5	28
Average of 12 analyses of water from Chalk beneath London clay	73·49	·095	·028	·052	·091	·352	12·18	8·5	8·6	17·1

It should, however, be mentioned that five of the deep well waters in the second series are evidently so much polluted by contamination with sewage that they should be omitted for the purpose of the above comparison, the results of the remaining 33 analyses agreeing more closely with those of the spring waters. The average of the total solids in solution in the well waters is then 35·11; the average temporary hardness is 20·1, and that of the total hardness is 26·39.

Mr. R. B. Hayward has dealt with this matter in a paper "On the Water in the Chalk beneath the London Clay,"* to which the reader is referred for a good summary of the subject. He also gave a table of analyses of the contents of 16 different well waters, and he subsequently, at Mr. Whitaker's desire, reduced the analyses of other well waters to the same common form, the extended table being printed in the Appendix to Mr. Whitaker's memoir on the Geology of London.†

Writing in 1888 and referring to the great difference between the water from uncovered chalk and that of the deeply-covered chalk, Mr. Whitaker remarked that no satisfactory explanation had yet been given and that further investigation was needed.‡ He takes note of the supposition that "some of the salts, such as the sodium chloride, may be the remains of the salt of the old ocean in which the chalk was deposited,"§ but observes that if so, "one might have expected to find them at great depths in the chalk where it is not covered by the Tertiary Beds."

He then thought it more probable that the quality of the water in the chalk beneath the Tertiaries was due to inter-communication between the water in the chalk and that in the overlying Tertiary sands, whereby "the water in the former has become charged with some of the saline constituents of those sands, whether original or produced by chemical alterations going on at great depths where the beds are saturated with water."

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* Middlesex Nat. Hist. Soc., 1887, p. 48–63.

† "The Geology of London," Mem. Geol. Survey, Vol. i. table opposite p. 533.

‡ "Geology of London, etc.," Vol. i. p. 514 (1889).

§ Sir J. Prestwich held this view (see his "Water-bearing Strata of London," 1851, p. 220).

At the time when the remarks above quoted were published, Mr. Whitaker was unaware that the subject had been discussed by Mr. R. Warrington in 1887,* but on the occasion of an address to the Hertfordshire Natural History society in 1898,† he drew attention to Mr. Warrington's paper as containing a better explanation of the facts than the one he had suggested.

Mr. Warrington was specially dealing with the waters of the deep wells at Harpenden in Herts, and on comparing the results of his analyses with those of other well waters he was struck by the small amount of chlorine occurring in the Harpenden water. He says : " It would appear that there is some peculiarity in the chalk water of Harpenden so far as its contents in chlorides are concerned. I venture to think that the low proportion of chlorides in the pure well-waters of Harpenden may be due to the situation of the village not far from the escarpment of the Chalk at the northern edge of the Thames basin. The Chalk here being at a considerable elevation (344 to 430 feet above the sea), and the gradient of the underground water-level very considerable, the chalk-rock has been in the course of ages washed very thoroughly by the percolation of rain, and the chlorides originally present in the rock when upheaved from the sea have been almost completely removed."

"The wells in the lower part of the chalk-basin are obviously supplied to a considerable extent by the underground drainage from the upper part of the basin. This underground drainage water when it passes Harpenden contains about 11 parts of chlorine per million of water; but as it continues to percolate through masses of chalk at a great distance from the surface, it may be assumed to gain chlorides from the small residue of common salt remaining in the rock, so that wells in the lower part of the basin should on an average contain water richer in chlorides than wells at the edge of the basin". . . . . .

" Direct evidence as to the presence of common salt in the Chalk seems to be furnished by the general considerable excess of chlorides in contaminated well waters over the amount furnished by rain and present in the waters of land-drainage." [This point he had previously proved.] Still stronger evidence is supplied by the condition of the well-waters in the Chalk when this formation is covered by the London Clay. The clay has, of course, prevented any percolation of rain from above; the washing of this chalk has, therefore been confined for many ages to the slow passage through it of water from the upper part of the basin already containing chlorides. Under these circumstances we find a well-water extremely rich in chlorides. Frankland found, as a mean of

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* Journ. Chem. Soc., Vol. li., p. 500.

† "The Chalk Water in Hertfordshire," Trans. Hert. Nat. Hist. Soc., Vol. x.

13 well-waters, 150·2 parts of chlorine per million of water; and this richness in chlorides occurs in wells now far removed from the sea."

I may mention that the same explanation had occurred to me before reading Mr. Warrington's paper or Mr. Whitaker's reference to it, and that I had formulated it in the following terms. Assuming that some sodium chloride was embedded and occluded in the Chalk, and also that originally it was equally disseminated throughout the formation, it is clear that it would be more or less completely leached out of all those portions of the chalk which were uptilted and so became exposed to the continual action of percolating fresh water. But in the central portions of the synclines beneath the Tertiaries, where the Chalk has probably been always saturated with water, there could not be the same rapid extraction of the sodium chloride. It is true that under the London Basin there is probably a certain movement of water eastward toward the sea, but it must be very slow, for there is not likely to be any free exit for it beneath the North Sea. Thus it seems quite possible that in such portions of the Chalk that are well below the sea level, much of the original sodium chloride may still remain in solution, and it is possible even that the amount has been increased in some places by that whch has been leached out from higher levels.

It may also be observed that the increase of saline contents in the water found below London must not be considered as an isolated case; there is probably a similar increase in the case of other formations, notably in water from the Lower Greensand in Oxfordshire and from the Coral Rag at Swindon.*

In his address above mentioned Mr. Whitaker remarks: "It seems to me that the above is a good explanation, and the more so as it accounts for like occurrences (sometimes of a stronger kind) in other formations than the Chalk. The washing out of the salts from the Chalk from the escarpment downward to the central parts of the basin where concentration would take place; the possible addition there of salts derived from the Tertiary sands (between the London Clay and the Chalk); and perhaps some chemical changes slowly brought about in the deep-seated water; these would seem to be enough to account for the great differences in the mineral contents of the waters in the open and in the covered chalk."

It should, however, be mentioned that still more recently another suggestion has been made which deserves notice, inasmuch as it comes from a good chemist. Dr. J. C. Thresh, in a paper on "The Saline Constituents of Chalk Waters,"† writes as follows:—

"My view is that this water is practically stagnant under the country, and that in the course of ages the action between the water which entered on the west from the Chalk outcrop and the sea-water which entered on the east from the opposite outcrop under the ocean has resulted in the formation of these particular fonstituents." He thinks that "very little of this water comes rom the outcrop to the west," and that as the multiplication of deep wells continues to reduce the water-level, "the sea-water will travel inland faster than the reactions which have produced the saline constituents of the water now in the chalk can keep pace with."

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* See Jukes-Browne "On a Boring at Shillingford," Midland Naturalist, Vol. xiv. p. 201 (1891), and H. B. Woodward "On a Well-sinking at Swindon, Quart. Journ. Geol. Soc., Vol. lii. p. 289 (1885).

† "The Journal of State Medicine," Vol. vii. p. 437, 1899.

He also remarks that some of his analyses show a great variation in the contents of chalk-water even in the same parish, and observes that "such great variation over so limited an area does not point to free inter-communication, nor to a continuous flow of underground water in any direction. It points rather to a condition approaching stagnation allowing local influences to exert a maximum effect." Again he says: "I can discover no indication of this alkaline water travelling in any direction, and in my opinion it is a vast and practically stagnant underground reservoir which, if drawn from, is much more likely to be fed with sea-water from the east than by the rainfall on the outcrop to the west."

Dr. Thresh may be right in concluding that the water in the deeper parts of the Chalk Basin is in a "condition approaching stagnation," but I think few geologists will agree that very little of the water comes from the outcrop on the west. He admits that some may enter South Essex from the outcrop in Kent, but thinks that most of the Kent water which passes northward is forced out through fissures into the bed of the Thames

He writes as if he thought there was an outcrop of Chalk beneath the bed of the North Sea, whereas the fact is that the Tertiaries of the London Basin are continued eastward beneath that sea into Belgium and Holland. The head of fresh water flowing continually into the subterranean extension of the Chalk from the outcrops on the south, the west and the north-west probably affords a much greater general pressure than is needed to keep sea-water from flowing into the basin, from the few points where chalk does come into contact with the sea. These are (1) around Grays and Gravesend, (2) in the Isle of Thanet, (3) near Cromer, in Norfolk. It is quite true that in these localities sea water does make its way into the wells after continued pumping, but this is only because the pressure of the head of fresh water has been reduced by the pumping, and the result is entirely a local one.

If Dr. Thresh's view were correct, one would expect that his tables of analyses would show a general increase of saline constituents as one travelled in the direction of the sea, and especially an increase in the amount of sodium chloride, but such does not appear to be the case. Thus there are eight instances in Essex in which the total quantity of salts amount to over 100 parts per 100,000, and of these six are inland places, and only two (Wivenhoe and Clacton) are near the sea; yet in all of them the amount of sodium chloride is over 50 per cent. of the total, and in the case of Thorpe it is 67 per cent.

All the facts adduced by Dr. Thresh are indeed more satisfactorily explained on the theory of embedded salts than on the supposition of interaction with sea water now in process of diffusion. But his tables of analyses, which the proportions of the different salts existing in water from many localities, are very valuable, and represent the results of no fewer than 72 analyses. Some of these are quoted in the two following tables, the first one containing sixteen of Dr. Thresh's analyses of well waters in exposed chalk, and the second sixteen examples of water from below the Tertiary Beds in Essex.

TABLE I.—SALINE CONSTITUENTS IN WATER FROM WELLS IN EXPOSED AREAS OF CHALK. In parts per 100,000.

Localities.	Calcium carbonate.	Calcium sulphate.	Calcium nitrate.	Calcium chloride.	Magnesium carbonate.	Magnesium chloride.	Sodium carbonate.	Sodium sulphate.	Sodium chloride.	Sodium nitrate.	Silica, &c.	Total Solids.
Luton - - -	20·3	1·85	4·1	·95	—	—	—	—	1·5	—	1·65	30·0
Berkhampstead -	20·25	·45	2·4	—	—	—	—	—	2·15	—	1·25	26·5
Watford - -	25·3	3·40	5·8	—	—	1·2	—	—	2·3	—	1·5	39·5
Reading - -	26·35	·85	3·5	·8	—	·8	—	—	·65	—	1·55	34·5
Marlborough -	21·2	·35	2·35	—	—	·4	—	—	1·2	—	1·5	27·0
Andover - -	21·35	1·15	4·9	—	—	·4	—	—	2·15	—	2·05	32·0
Salisbury Plain -	19·	·4	1·7	·95	—	—	—	—	1·15	—	1·3	24.5
Warminster -	19·	1·1	2·9	1·6	—	·6	—	—	—	—	—	26·5
Broughton - -	17·75	1·65	3·0	—	—	1·0	—	—	1·4	—	2·7	27·5
Winchester - -	19·5	·9	5·9	—	—	1·2	—	—	1·3	—	·7	29·5
Owlesbury - -	18·3	·55	2·9	1·0	—	·5	—	—	·4	—	3·35	27·0
Otterbourne -	22·	·7	2·25	1·4	—	·6	—	—	·25	—	3·3	30·5
Havant - -	28·8	·7	2·55	·85	—	·8	—	—	·75	—	1·05	27·5
Brighton - -	16·	2·4	2·15	·55	—	·6	—	—	2·0	—	1·3	25·0
Do. - -	14·5	3·2	4·45	·55	—	1·0	—	—	3·6	—	1·2	28·5
Eastbourne - -	18·8	·55	2·4	3·9	—	1·2	—	—	3·85	—	1·3	29·0

TABLE II.—SALINE CONSTITUENTS OF CHALK WATERS FROM DEEP WELLS IN ESSEX. In parts per 100,000.

Localities.	Calcium carbonate.	Calcium sulphate.	Calcium nitrate.	Calcium chloride.	Magnesium carbonate.	Magnesium chloride.	Sodium carbonate.	Sodium sulphate.	Sodium. chloride.	Sodium nitrate.	Silica.	Total Solids.
Leigh - - -	1·4	—	—	—	1·05	—	26·6	8·0	42·7	·35	1·35	81·5
Brentwood -	1·5	—	—	—	1·05	—	28·15	13·6	20·3	·3	·6	65·5
Laindon Street -	1·5	—	—	—	1·05	—	26·2	9·5	34·5	·2	1·05	74·0
Chelmsford -	1·5	—	—	—	1·75	—	32·6	12·45	54·1	—	—	102·0
Fobbing - -	1·8	—	—	—	·85	—	22·95	17·3	28·85	—	1·25	73·0
Southend - -	1·9	—	—	—	1·4	—	23·3	8·6	52·95	·25	1·6	90·0
Vange - -	2·0	—	—	—	1·25	—	25·4	10·65	30·7	·25	1·75	72·0
Havering - -	2·1	—	—	—	1·2	—	26·65	15·85	22·1	—	2·6	70·5
W. Bergholt -	2·5	—	—	—	4·55	—	28·7	14·5	68·65	·55	—	119·5
Tiptree - -	2·3	—	—	—	2·8	—	40·95	26·35	97·2	·4	1·0	171·0
Great Bromley -	3·25	—	—	—	3·5	—	25·15	14·8	80·5	·4	·9	128·5
Felstead - -	3·5	—	—	—	3·5	—	26·9	16·0	40·1	·25	·25	90·5
Wyvenhoe - -	4·0	—	—	—	4·2	—	22·6	19·25	68·0	·55	—	118·5
Braintree - -	4·75	—	—	—	5·1	—	18·9	11·5	68·3	—	·95	109·5
Barking - -	5·25	—	—	—	1·4	—	14·9	9·85	6·95	1·5	1·65	41·5
Clacton - -	5·25	—	—	—	4·2	—	22·0	16·1	61·7	2·6	2·65	114·5

There is another aspect of the question which has been touched upon by Mr. Whitaker, and which he puts as follows:—"If the view is right which I am induced to take, or indeed if any view of purely local origin is right, one would expect that the alkaline salts should decrease by continuous extraction of the water," and Mr. Hayward gives some evidence to that effect. He says that "the well at the Harrow Waterworks was sunk with such care to exclude the water from the sands . . . . above the chalk, that there can be no doubt that we are dealing in this case with water from the chalk alone," and he notes the following general results of analyses at different times, adding that "this appears to show a progressive improvement in the water."

In 1868,	total solid contents	1,044.	Hardness	48·5;
In 1870	„ „ „	1,009.	„	44·4.
In 1873	„ „ „	981.	„	40·8.
In 1883	„ „ „	884.	„	38·5 or 34·3 (?).

Mr. Hayward also remarks that "it would be interesting to examine whether the softening [of the underground water] is regularly progressive as the water passes inwards from the outcrop." That this is the case seems to be indicated by the analyses which were arranged by Mr. Hayward, and printed in Mr. Whitaker's memoir, when these analyses are grouped as follows:—

Group A.—Waters from below bare chalk in Herts and Surrey.
Group B.—Waters from below covered chalk in Kent and Surrey.
Group C.—Waters from below covered chalk in Central London.
Group D.—Waters from below covered chalk north of London.

Group A includes only four analyses, but they are fairly representative; for each of the other groups I have taken the results of eight analyses, and calculated the averages of the several ingredients. These come out as follows:—

Average contents of different groups of Well Waters expressed in Parts per 100,000.

	Group A.	Group B.	Group C.	Group D.
Calcium - - - - -	10·62	7·6	2·25	4·7
Magnesium - - - -	·45	1·27	·8	4·3
Sodium - - - - -	1·12	6·92	23·5	15·0
Potash - - - - -	–	1·3	6·2	2·9
Carbonic acid - - - -	15·25	16·1	21·7	19·3
Sulphuric acid - - -	·92	7·36	18·9	18·8
Chlorine - - - - -	1·25	3·4	15·4	9·5
Nitric acid - - - -	1·6	–	–	–
Silica - - - - -	1·2	1·0	1.6	1·5
Organic matter - - -	1·67	·9	.5	2·1
Totals - - - -	34·08	45·85	90·85	78·1

It will be seen that the contents of groups C and D differ greatly from those of the other two, and do not differ very much from one another except in the proportions of sodium and chlorine, there being evidently more sodium chloride in the water under London than in the area further north.

Still more recently Mr. W. W. Fisher has written on this subject* and he is of the same opinion as Mr. Warington, Mr. Whitaker and myself. He points out that even if infiltration from the sea were possible in some parts of Essex, it could hardly be the explanation at Wokingham in Berkshire, where the water derived from the Chalk is markedly alkaline and contains as much as 25 grains per gallon of chlorine (in chlorides).

Mr. Fisher believes that all the sodium salts found in deep-seated waters from the Chalk of the London Basin have been derived from the soluble salts retained by and occluded in the mass of the Chalk, and have been gradually taken up into solution by the percolating water in its progress from the marginal outcrops of the Chalk into the central parts of the Basin. He thinks that during this progress "the proportion of alkaline carbonates will gradually increase, and as it increases the calcium salts will diminish until mere traces only are left. . . . . The amount of calcium carbonate in solution will ultimately depend on the amounts of carbonic acid in the water available as a solvent, so that some of the alkaline chalk-waters are harder than others for this reason."

In order to test the existence of sodium salts in the Chalk itself, he obtained samples of Chalk taken from the boring at Meux's Brewery, in Tottenham Court Road, and analysed that taken from a depth of 500 feet with the following results:—

Calcium as carbonate	93·90
Silica (including soluble silica)	4·20
Iron oxide (with P_2O_5)	·50
Magnesium carbonate	·70
Sodium sulphate	·28
Sodium chloride	·20
Sodium carbonate	·03
Water and loss	·19
	100·00

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* "On Alkaline Waters from the Chalk," The Analyst (August, 1901).

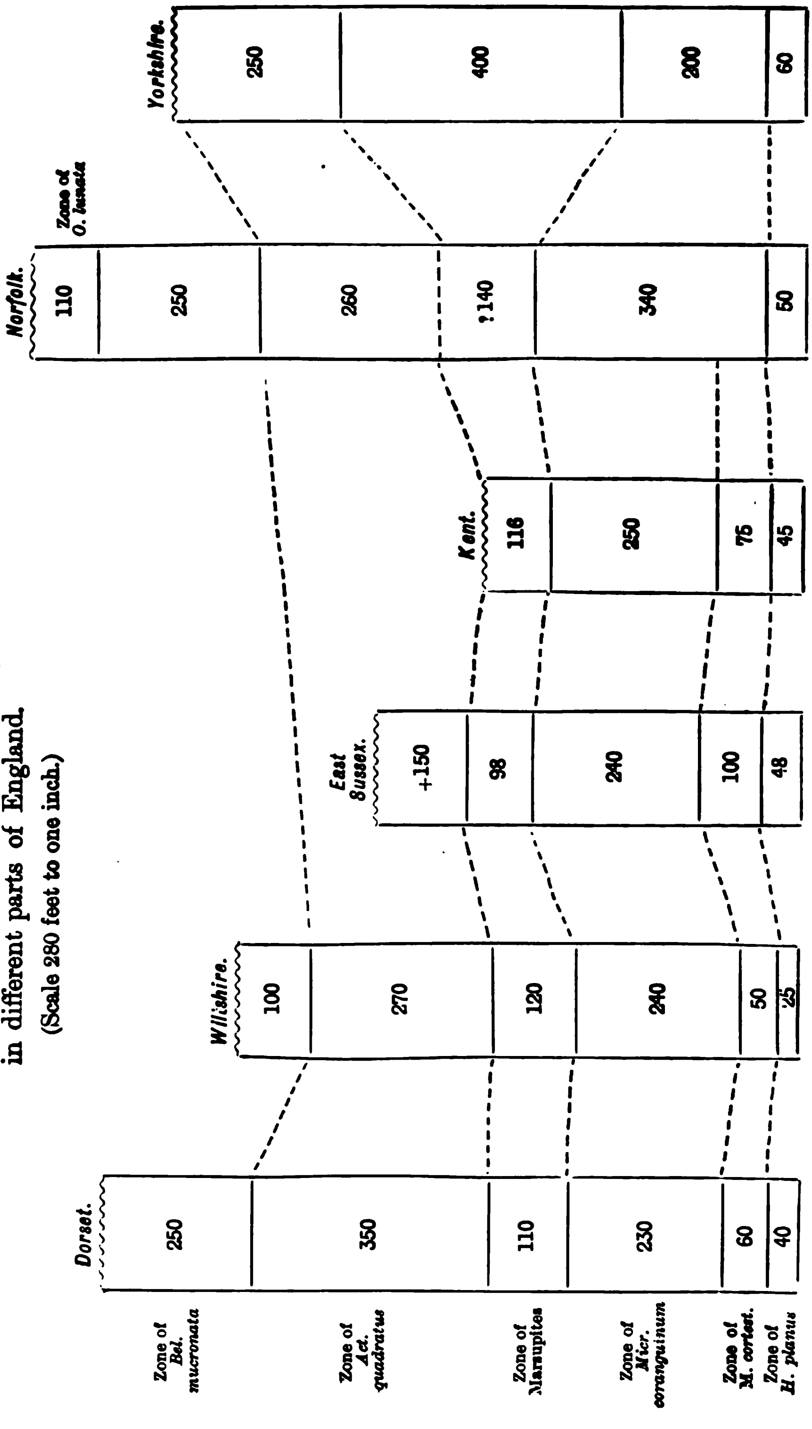

FIG. 79.—Comparative Vertical Sections of the Upper Chalk in different parts of England.
(Scale 280 feet to one inch.)

APPENDIX I.—PALÆONTOLOGY.

A.—CRITICAL REMARKS ON SOME SPECIES OF FOSSILS.

By E. T. Newton and A. J. Jukes-Browne.

Cephalopoda.

Actinocamax lanceolatus, *Sow.*

1829. Belemnites lanceolatus, *Sow.* Min. Con., pl. 600, figs, 8, 9.
non Belemnites lanceolatus, *Schloth.* Petref., p. 49, No. 8.

The Belemnite figured by Sowerby under the name of *lanceolatus* seems to have been overlooked by most writers, and specimens have hitherto been generally regarded as a variety of *Belemnites plenus*, Blainv.

It is true that the young forms of *Bel.* (*Actinocamax*) *plenus* are not inflated like the adult individuals, but are narrow and not unlike the species figured by Sowerby, but Sowerby's types came from the Chalk Marl of Hamsey, and specimens with unquestionably the same form occur not unfrequently in the Chalk Marl of Folkestone and in the Totternhoe Stone of Bedfordshire and Cambridgeshire, whereas typical inflated examples of *Actinocamax plenus* have never yet been obtained from the zone of *Ammonites varians*. The Chalk Marl form is, moreover, rather stouter for its length and has its sides more continuously parallel.

As it is an *Actinocamax* and not a *Belemnitella*, and as the former is now recognised as a distinct genus, it can retain the specific name given to it by Sowerby. Sharpe (Pal. Soc., Chalk Cephalopoda) confused this form with the true *Act. plenus* (Blainv.).

Actinocamax Toucasi, *Janet.*

1891. Actinocamax Toucasi, *Janet.* Bull. Soc. Géol. Fr., Ser. iii., Vol. xix. p. 719.

This species has been identified by Mr. G. C. Crick from a specimen in Dr. Blackmore's collection obtained from Harnham, near Salisbury. It resembles *Act. plenus* in many respects, having somewhat similar swelling outlines, but is wider laterally than from front to back, while in *Act. plenus* the reverse is the case.

The type was obtained from the base of the *Act. quadratus* zone in France, and the Salisbury specimen is from the same zone.

At the time when the remarks above quoted were published, Mr. Whitaker was unaware that the subject had been discussed by Mr. R. Warrington in 1887,* but on the occasion of an address to the Hertfordshire Natural History society in 1898,† he drew attention to Mr. Warrington's paper as containing a better explanation of the facts than the one he had suggested.

Mr. Warrington was specially dealing with the waters of the deep wells at Harpenden in Herts, and on comparing the results of his analyses with those of other well waters he was struck by the small amount of chlorine occurring in the Harpenden water. He says : " It would appear that there is some peculiarity in the chalk water of Harpenden so far as its contents in chlorides are concerned. I venture to think that the low proportion of chlorides in the pure well-waters of Harpenden may be due to the situation of the village not far from the escarpment of the Chalk at the northern edge of the Thames basin. The Chalk here being at a considerable elevation (344 to 430 feet above the sea), and the gradient of the underground water-level very considerable, the chalk-rock has been in the course of ages washed very thoroughly by the percolation of rain, and the chlorides originally present in the rock when upheaved from the sea have been almost completely removed."

"The wells in the lower part of the chalk-basin are obviously supplied to a considerable extent by the underground drainage from the upper part of the basin. This underground drainage water when it passes Harpenden contains about 11 parts of chlorine per million of water; but as it continues to percolate through masses of chalk at a great distance from the surface, it may be assumed to gain chlorides from the small residue of common salt remaining in the rock, so that wells in the lower part of the basin should on an average contain water richer in chlorides than wells at the edge of the basin ". . . . . .

" Direct evidence as to the presence of common salt in the Chalk seems to be furnished by the general considerable excess of chlorides in contaminated well waters over the amount furnished by rain and present in the waters of land-drainage." [This point he had previously proved.] Still stronger evidence is supplied by the condition of the well-waters in the Chalk when this formation is covered by the London Clay. The clay has, of course, prevented any percolation of rain from above ; the washing of this chalk has, therefore been confined for many ages to the slow passage through it of water from the upper part of the basin already containing chlorides. Under these circumstances we find a well-water extremely rich in chlorides. Frankland found, as a mean of

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In his address above mentioned Mr. Whitaker remarks: "It seems to me that the above is a good explanation, and the more so as it accounts for like occurrences (sometimes of a stronger kind) in other formations than the Chalk. The washing out of the salts from the Chalk from the escarpment downward to the central parts of the basin where concentration would take place; the possible addition there of salts derived from the Tertiary sands (between the London Clay and the Chalk); and perhaps some chemical changes slowly brought about in the deep-seated water; these would seem to be enough to account for the great differences in the mineral contents of the waters in the open and in the covered chalk."

It should, however, be mentioned that still more recently another suggestion has been made which deserves notice, inasmuch as it comes from a good chemist. Dr. J. C. Thresh, in a paper on "The Saline Constituents of Chalk Waters,"† writes as follows:—

"My view is that this water is practically stagnant under the country, and that in the course of ages the action between the water which entered on the west from the Chalk outcrop and the sea-water which entered on the east from the opposite outcrop under the ocean has resulted in the formation of these particular constituents." He thinks that "very little of this water comes from the outcrop to the west," and that as the multiplication of deep wells continues to reduce the water-level, "the sea-water will travel inland faster than the reactions which have produced the saline constituents of the water now in the chalk can keep pace with."

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* See Jukes-Browne "On a Boring at Shillingford," Midland Naturalist, Vol. xiv. p. 201 (1891), and H. B. Woodward "On a Well-sinking at Swindon, Quart. Journ. Geol. Soc., Vol. lii. p. 289 (1885).

† "The Journal of State Medicine," Vol. vii. p. 437, 1899.

He also remarks that some of his analyses show a great variation in the contents of chalk-water even in the same parish, and observes that "such great variation over so limited an area does not point to free inter-communication, nor to a continuous flow of underground water in any direction. It points rather to a condition approaching stagnation allowing local influences to exert a maximum effect." Again he says: "I can discover no indication of this alkaline water travelling in any direction, and in my opinion it is a vast and practically stagnant underground reservoir which, if drawn from, is much more likely to be fed with sea-water from the east than by the rainfall on the outcrop to the west."

Dr. Thresh may be right in concluding that the water in the deeper parts of the Chalk Basin is in a "condition approaching stagnation," but I think few geologists will agree that very little of the water comes from the outcrop on the west. He admits that some may enter South Essex from the outcrop in Kent, but thinks that most of the Kent water which passes northward is forced out through fissures into the bed of the Thames

He writes as if he thought there was an outcrop of Chalk beneath the bed of the North Sea, whereas the fact is that the Tertiaries of the London Basin are continued eastward beneath that sea into Belgium and Holland. The head of fresh water flowing continually into the subterranean extension of the Chalk from the outcrops on the south, the west and the north-west probably affords a much greater general pressure than is needed to keep sea-water from flowing into the basin, from the few points where chalk does come into contact with the sea. These are (1) around Grays and Gravesend, (2) in the Isle of Thanet, (3) near Cromer, in Norfolk. It is quite true that in these localities sea water does make its way into the wells after continued pumping, but this is only because the pressure of the head of fresh water has been reduced by the pumping, and the result is entirely a local one.

If Dr. Thresh's view were correct, one would expect that his tables of analyses would show a general increase of saline constituents as one travelled in the direction of the sea, and especially an increase in the amount of sodium chloride, but such does not appear to be the case. Thus there are eight instances in Essex in which the total quantity of salts amount to over 100 parts per 100,000, and of these six are inland places, and only two (Wivenhoe and Clacton) are near the sea; yet in all of them the amount of sodium chloride is over 50 per cent. of the total, and in the case of Thorpe it is 67 per cent.

All the facts adduced by Dr. Thresh are indeed more satisfactorily explained on the theory of embedded salts than on the supposition of interaction with sea water now in process of diffusion. But his tables of analyses, which the proportions of the different salts existing in water from many localities, are very valuable, and represent the results of no fewer than 72 analyses. Some of these are quoted in the two following tables, the first one containing sixteen of Dr. Thresh's analyses of well waters in exposed chalk, and the second sixteen examples of water from below the Tertiary Beds in Essex.

TABLE I.—SALINE CONSTITUENTS IN WATER FROM WELLS IN EXPOSED AREAS OF CHALK. In parts per 100,000.

Localities.	Calcium carbonate.	Calcium sulphate.	Calcium nitrate.	Calcium chloride.	Magnesium carbonate.	Magnesium chloride.	Sodium carbonate.	Sodium sulphate.	Sodium chloride.	Sodium nitrate.	Silica, &c.	Total Solids.
Luton - - -	20·3	1·85	4·1	·95	—	—	—	—	1·5	—	1·65	30·0
Berkhampstead -	20·25	·45	2·4	—	—	—	—	—	2·15	—	1·25	26·5
Watford - -	25·3	3·40	5·8	—	—	1·2	—	—	2·3	—	1·5	39·5
Reading - -	26·35	·85	3·5	·8	—	·8	—	—	·65	—	1·55	34·5
Marlborough -	21·2	·35	2·35	—	—	·4	—	—	1·2	—	1·5	27·0
Andover - -	21·35	1·15	4·9	—	—	·4	—	—	2·15	—	2·05	32·0
Salisbury Plain -	19·	·4	1·7	·95	—	—	—	—	1·15	—	1·3	24.5
Warminster -	19·	1·1	2·9	1·6	—	·6	—	—	—	—	—	26·5
Broughton - -	17·75	1·65	3·0	—	—	1·0	—	—	1·4	—	2·7	27·5
Winchester - -	19·5	·9	5·9	—	—	1·2	—	—	1·3	—	·7	29·5
Owlesbury - -	18·3	·55	2·9	1·0	—	·5	—	—	·4	—	3·35	27·0
Otterbourne -	22·	·7	2·25	1·4	—	·6	—	—	·25	—	3·3	30·5
Havant - -	28·8	·7	2·55	·85	—	·8	—	—	·75	—	1·05	27·5
Brighton - -	16·	2·4	2·15	·55	—	·6	—	—	2·0	—	1·3	25·0
Do. - -	14·5	3·2	4·45	·55	—	1·0	—	—	3·6	—	1·2	28·5
Eastbourne - -	18·3	·55	2·4	3·9	—	1·2	—	—	3·85	—	1·3	29·0

TABLE II.—SALINE CONSTITUENTS OF CHALK WATERS FROM DEEP WELLS IN ESSEX. In parts per 100,000.

Localities.	Calcium carbonate.	Calcium sulphate.	Calcium nitrate.	Calcium chloride.	Magnesium carbonate.	Magnesium chloride.	Sodium carbonate.	Sodium sulphate.	Sodium. chloride.	Sodium nitrate.	Silica.	Total Solids.
Leigh - - -	1·4	—	—	—	1·05	—	26·6	8·0	42·7	·35	1·35	81·5
Brentwood -	1·5	—	—	—	1·05	—	28·15	13·6	20·3	·3	·6	65·5
Laindon Street -	1·5	—	—	—	1·05	—	26·2	9·5	34·5	·2	1·05	74·0
Chelmsford -	1·5	—	—	—	1·75	—	32·6	12·45	54·1	—	—	102·0
Fobbing - -	1·8	—	—	—	·85	—	22·95	17·3	28·85	—	1·25	73·0
Southend - -	1·9	—	—	—	1·4	—	23·3	8·6	52·95	·25	1·6	90·0
Vange - -	2·0	—	—	—	1·25	—	25·4	10·65	30·7	·25	1·75	72·0
Havering - -	2·1	—	—	—	1·2	—	26·65	15·85	22·1	—	2·6	70·5
W. Bergholt -	2·5	—	—	—	4·55	—	28·7	14·5	68·65	·55	—	119·5
Tiptree - -	2·3	—	—	—	2·8	—	40·95	26·35	97·2	·4	1·0	171·0
Great Bromley -	3·25	—	—	—	3·5	—	25·15	14·8	80·5	·4	·9	128·5
Felstead - -	3·5	—	—	—	3·5	—	26·9	16·0	40·1	·25	·25	90·5
Wyvenhoe - -	4·0	—	—	—	4·2	—	22·6	19·25	68·0	·55	—	118·5
Braintree - -	4·75	—	—	—	5·1	—	18·9	11·5	68·3	—	·95	109·5
Barking - -	5·25	—	—	—	1·4	—	14·9	9·85	6·95	1·5	1·65	41·5
Clacton - -	5·25	—	—	—	4·2	—	22·0	16·1	61·7	2·6	2·65	114·5

There is another aspect of the question which has been touched upon by Mr. Whitaker, and which he puts as follows:—"If the view is right which I am induced to take, or indeed if any view of purely local origin is right, one would expect that the alkaline salts should decrease by continuous extraction of the water," and Mr. Hayward gives some evidence to that effect. He says that "the well at the Harrow Waterworks was sunk with such care to exclude the water from the sands . . . . above the chalk, that there can be no doubt that we are dealing in this case with water from the chalk alone," and he notes the following general results of analyses at different times, adding that "this appears to show a progressive improvement in the water."

In 1868, total solid contents 1,044. Hardness 48·5;
In 1870 „ „ „ 1,009. „ 44·4.
In 1873 „ „ „ 981. „ 40·8.
In 1883 „ „ „ 884. „ 38·5 or 34·3 (?).

Mr. Hayward also remarks that "it would be interesting to examine whether the softening [of the underground water] is regularly progressive as the water passes inwards from the outcrop." That this is the case seems to be indicated by the analyses which were arranged by Mr. Hayward, and printed in Mr. Whitaker's memoir, when these analyses are grouped as follows:—

Group A.—Waters from below bare chalk in Herts and Surrey.
Group B.—Waters from below covered chalk in Kent and Surrey.
Group C.—Waters from below covered chalk in Central London.
Group D.—Waters from below covered chalk north of London.

Group A includes only four analyses, but they are fairly representative; for each of the other groups I have taken the results of eight analyses, and calculated the averages of the several ingredients. These come out as follows:—

Average contents of different groups of Well Waters expressed in Parts per 100,000.

	Group A.	Group B.	Group C.	Group D.
Calcium - - - -	10·62	7·6	2·25	4·7
Magnesium - - -	·45	1·27	·8	4·3
Sodium - - - -	1·12	6·92	23·5	15·0
Potash - - - -	–	1·3	6·2	2·9
Carbonic acid - - -	15·25	16·1	21·7	19·3
Sulphuric acid - -	·92	7·36	18·9	18·8
Chlorine - - - -	1·25	3·4	15·4	9·5
Nitric acid - - -	1·6	–	–	–
Silica - - - -	1·2	1·0	1.6	1·5
Organic matter - -	1·67	·9	.5	2·1
Totals - - -	34·08	45·85	90·85	78·1

It will be seen that the contents of groups C and D differ greatly from those of the other two, and do not differ very much from one another except in the proportions of sodium and chlorine, there being evidently more sodium chloride in the water under London than in the area further north.

Still more recently Mr. W. W. Fisher has written on this subject* and he is of the same opinion as Mr. Warington, Mr. Whitaker and myself. He points out that even if infiltration from the sea were possible in some parts of Essex, it could hardly be the explanation at Wokingham in Berkshire, where the water derived from the Chalk is markedly alkaline and contains as much as 25 grains per gallon of chlorine (in chlorides).

Mr. Fisher believes that all the sodium salts found in deep-seated waters from the Chalk of the London Basin have been derived from the soluble salts retained by and occluded in the mass of the Chalk, and have been gradually taken up into solution by the percolating water in its progress from the marginal outcrops of the Chalk into the central parts of the Basin. He thinks that during this progress "the proportion of alkaline carbonates will gradually increase, and as it increases the calcium salts will diminish until mere traces only are left. . . . . The amount of calcium carbonate in solution will ultimately depend on the amounts of carbonic acid in the water available as a solvent, so that some of the alkaline chalk-waters are harder than others for this reason."

In order to test the existence of sodium salts in the Chalk itself, he obtained samples of Chalk taken from the boring at Meux's Brewery, in Tottenham Court Road, and analysed that taken from a depth of 500 feet with the following results:—

Calcium as carbonate	93 90
Silica (including soluble silica)	4·20
Iron oxide (with P_2O_5)	·50
Magnesium carbonate	·70
Sodium sulphate	·28
Sodium chloride	·20
Sodium carbonate	·03
Water and loss	·19
	100·00

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* "On Alkaline Waters from the Chalk," The Analyst (August, 1901).

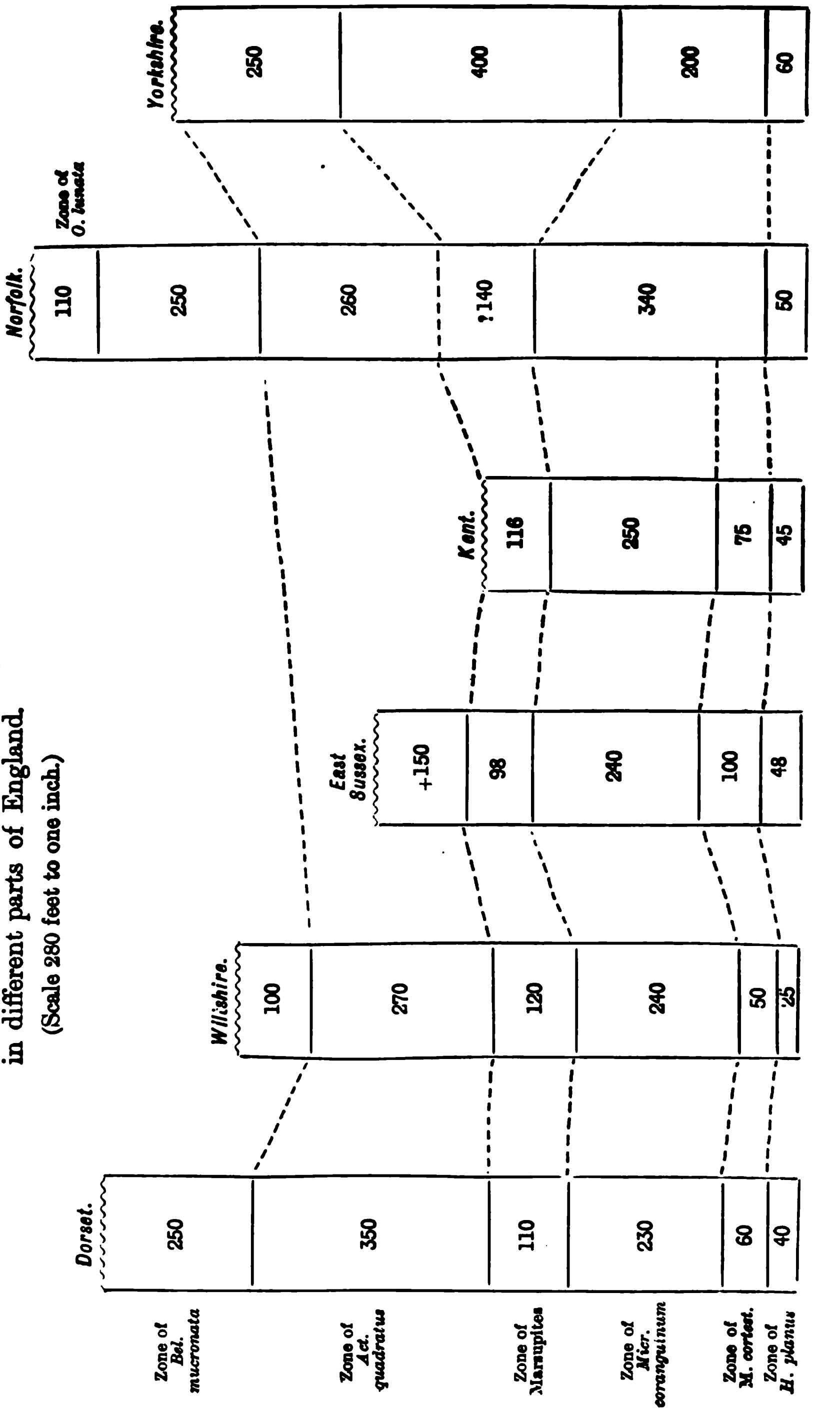

Fig. 79.—Comparative Vertical Sections of the Upper Chalk in different parts of England.

(Scale 280 feet to one inch.)

APPENDIX I.—PALÆONTOLOGY.

A.—CRITICAL REMARKS ON SOME SPECIES OF FOSSILS.

BY E. T. NEWTON AND A. J. JUKES-BROWNE.

Cephalopoda.

ACTINOCAMAX LANCEOLATUS, *Sow.*

1829. Belemnites lanceolatus, *Sow.* Min. Con., pl. 600, figs, 8, 9.
non Belemnites lanceolatus, *Schloth.* Petref., p. 49, No. 8.

The Belemnite figured by Sowerby under the name of *lanceolatus* seems to have been overlooked by most writers, and specimens have hitherto been generally regarded as a variety of *Belemnites plenus*, Blainv.

It is true that the young forms of *Bel.* (*Actinocamax*) *plenus* are not inflated like the adult individuals, but are narrow and not unlike the species figured by Sowerby, but Sowerby's types came from the Chalk Marl of Hamsey, and specimens with unquestionably the same form occur not unfrequently in the Chalk Marl of Folkestone and in the Totternhoe Stone of Bedfordshire and Cambridgeshire, whereas typical inflated examples of *Actinocamax plenus* have never yet been obtained from the zone of *Ammonites varians*. The Chalk Marl form is, moreover, rather stouter for its length and has its sides more continuously parallel.

As it is an *Actinocamax* and not a *Belemnitella*, and as the former is now recognised as a distinct genus, it can retain the specific name given to it by Sowerby. Sharpe (Pal. Soc., Chalk Cephalopoda) confused this form with the true *Act. plenus* (Blainv.).

ACTINOCAMAX TOUCASI, *Janet.*

1891. Actinocamax Toucasi, *Janet.* Bull. Soc. Géol. Fr., Ser. iii., Vol. xix. p. 719.

This species has been identified by Mr. G. C. Crick from a specimen in Dr. Blackmore's collection obtained from Harnham, near Salisbury. It resembles *Act. plenus* in many respects, having somewhat similar swelling outlines, but is wider laterally than from front to back, while in *Act. plenus* the reverse is the case.

The type was obtained from the base of the *Act. quadratus* zone in France, and the Salisbury specimen is from the same zone.

Gasteropoda.

SCALARIA DECORATA, VAR. FASCIATA, *Eth.*.

1841. Melania decorata, *Roemer*, Nordd. Kreidegeb., p. 82, Taf. 12, f. 11.
1843. Fusus costato-striatus, *Münster in Goldf.* Pet. Germ. iii., p. 23, Taf. 171, f. 18.
1845. Turrilites undulatus, *Reuss*, Bohm. Kreidef. i., Taf. 7, figs. 8, 9.
1850. Scalaria decorata, Sc. subundulata, and Sc. costato-striata in *d'Orbigny's* Prodrome ii., p. 217.
1872–75. Scala decorata, *Geinitz.* Elbthalg. in Sachsen, ii., p. 162, Taf. 29, fig. 4.
1881. Scalaria fasciata, *Etheridge* in Mem. Geol. Survey. Geology of Cambridge, p. 140, pl. 1, f. 1.

The above synonomy of *Scalaria decorata* is that given by Geinitz in the work quoted, he having reason to consider that the shells which d'Orbigny mentioned in his Prodrome under the names of *S. decorata*, *S. subundulata*, and *S. striato-costatus* are really the same species in different states of preservation.

Specimens from the Totternhoe Stone of Burwell were described and figured by Mr. Etheridge in 1881 under the name of *Sc. fasciata,* and he remarks their close resemblance to the *Fusus costato-striatus* of Münster, but thinks they differ in two respects, (1) in possessing a cord-like band at the suture, (2) in having more ventricose whorls; but the figure given by Geinitz has even more ventricose whorls than the Burwell specimens, and the sutural band is hardly of sufficient prominence to differentiate a species. The shell seems to agree in all other points with the *Scalaria decorata* as described by Geinitz, and so it is proposed to regard the English specimens as a variety of that species.

Lamellibranchiata.

INOCERAMUS LATUS, *Mant.* (non *d'Orb.*).

1822. Inoceramus latus, *Mant.* Foss. South Downs, Tab. 27, f. 10.
1828. Inoceramus latus, *Sow.* Min. Con., Tab. 582, f. 1.
1840. ? Inoceramus planus, *Münst.*, in *Goldf.* Pet. Germ., Taf. 113, f. 1.
non Inoceramus latus, *Goldf.* nec. *d'Orb.*
non Inoceramus latus, var. reachensis, *Eth.*

Mantell in describing this large species (Op. cit. p. 216) says that it equals *Inoc. Cuvieri* in length and width, but is depressed and destitute of the prominent costæ which distinguish that species. He also remarks that it is "common in the Upper Chalk near Brighton, Lewes, Offham, etc."

Sowerby gives a good figure showing an oblique shell with a straight hinge line and uniform undulations, obtained "from the Upper Chalk near Swaffham in Norfolk."

It is quite certain, therefore, that the original types of *Inoc. latus* were found in the Upper Chalk, or at any rate in the "chalk with flints," and neither Mantell nor Sowerby say anything about its occurrence in the "chalk without flints" or in the Chalk Marl.

There is no doubt that shells agreeing fairly well with the figures given by Mantell and Sowerby do occur in the Upper Chalk, and also that by some authors they have been wrongly referred to *Inoc. Cripsi*. This latter is distinctly stated by Mantell to be a Chalk Marl form found at Ringmer, Hamsey, and Offham. The name *Inoc. latus* must therefore be retained for the Upper Chalk form.

INOCERAMUS LATUS, *Goldf.* (non *Mant.*).

1840. Inoceramus latus, *Goldf.* Pet. Germ., Tab. 112, f. 5.
1846. Inoceramus latus, *d'Orb.* Pal. Fr., Terr. Crét. pl. 408, f. 1, 2.
1881. Inoceramus latus, var.. reachensis, *Etheridge*, in Mem. Geol. Surv., Geology of the Neighb. of Cambridge, pl. 1, f. 3.
non Inoceramus orbicularis, *Münst*, in *Goldf.*, pl. 113, f. 2.
non Inoceramus orbicularis, *Schlüter*, Zur Gattung Inoceramus, Palæontographica, Vol. xxiv. 1877, p. 260.
Query Inoceramus Cripsii, *Mant.* Foss. South Downs, Tab. 27, f. 11.

The shell identified by Goldfuss with the *Inoceramus latus* of Mantell is stated to occur in the "grey chalk and greensand of Westphalia," and was therefore probably obtained from beds equivalent to our Lower Chalk.

D'Orbigny's figure of *Inoc. latus* is so like that of Goldfuss that it might have been copied from the latter, and it appears among his Cenomanian, and not with his Senonian species. He refers to Mantell's figure, but does not seem to have compared French and English specimens, while his figure bears very little resemblance to Mantell's, which, as already stated, was a species from the Upper Chalk not the Lower Chalk.

Schlüter in 1877 attempted to settle the synonomy of the Cretaceous *Inocerami*, but not very successfully. He thought that Mantell's name should be abandoned, and that the *Inoc. orbicularis* of Münster (in Goldfuss) was the same species as the shells figured by Goldfuss and d'Orbigny under the name of *I. latus*, so he proposes to use the name *I. orbicularis*. This view was adopted by Professor Barrois (Ann. Soc. Géol. Nord., t. v. p. 357).

We can agree with Schlüter and Barrois in believing that the shell found in the zone of *Ammonites varians* may be identified with the form figured by Goldfuss and d'Orbigny under the name of *In. latus*, and also agree with them that it cannot continue to bear that name; but we are quite unable to regard the *In. orbicularis* of Münster as the same species.

It is worthy of note that in a list of Sussex fossils drawn up by Mantell in 1828 (Geol. Trans., Ser. 2, Vol. iii. p. 201), he separated those of the "Chalk Marl" from those of the "Lower and Upper

Chalk," and in this list the only *Inocerami* mentioned as Chalk Marl species are *I. Cripsi* and *I. tenuis*. Further, some of the irregular varieties of the Chalk Marl shell more closely resemble the figure of *I. Cripsi* in Mantell's "Fossils of the South Downs" than that of *I. latus* in the same volume, and we think it very probable that the Cenomanian and Lower Chalk form, which has hitherto been known as *I. latus*, will prove to be really *I. Cripsi*.

INOCERAMUS PICTUS, *Sow.*

Inoceramus pictus, *Sow.* Min. Con., Tab. 604, f. 1.
? Inoceramus cuneiformis, *d'Orb.* Pal. Fr., Terr. Crét., pl. 407.

We desire to call attention to the *Inoc. pictus* of Sowerby because it seems to be a form which has escaped attention in England. It is elongate and straight, not oblique, like *I. mytiloides*, the anterior side is rather flat and smooth, and the valves are nearly equal and equally inflated. The type specimen bore longitudinal radiating bands of brownish colour, and is stated to have come from the Chalk Marl of Guildford. The figure of d'Orbigny's *I. cuneiformis* much resembles *I. pictus*, but we have not seen any French specimens, and to identify them it would be necessary to compare the types. A specimen, however, found by the Rev. W. R. Andrews near Westbury, in Wiltshire, resembles the figures of both forms and might be identified with either.

LIMA ASPERA, *Mant.*

1822. Plagiostoma aspera, *Mantell.* Geol. Sussex, p. 129, pl. 26, f. 18.
1846. Lima plana, *Reuss* (non *Roemer*). Bohm. Kreidef., p. 35, Taf. 38, f. 20.
non Lima aspera of *Goldfuss, d'Orbigny*, nec *Reuss.*

The true *Lima aspera* is found in the Chalk Marl of southern and central England and in the Totternhoe Stone. It has never yet been well figured and distinguished from the species confused with it by Goldfuss and d'Orbigny; but a figure of it has been given in Vol. II., p. 30, of this memoir.

The following is the description given by Mantell: "56. *Plagiostoma* (?) *aspera*. Tab. xxvi. fig. 18. Subdepressed, obovate, with numerous longitudinal aculeated sulci.":—

> "To the naked eye this shell appears as if marked with smooth, longitudinal striæ, but conveys a sensation of roughness to the touch. With the assistance of a lens, the striæ are perceived to be sulci [i.e. grooves] dividing the surface into flat ribs, the edges of which are fringed with minute sharp points.
>
> "It has a few irregular lines of growth: the structure of the hinge is not shown in any of the specimens in my possession.
>
> "This shell bears considerable resemblance to *Lima spathula* of Lamarck.
>
> "Localities: Hamsey, Stoneham: rare."

Lima plana of Reuss seems to be the same form, but the *Lima aspera* of Reuss, Bohm, Kreidef ii. p. 34, Taf. 38, f. 17, which is a species with angular indentations forming a series of concentric ridges, is not the same, neither is the *aspera* of Goldfuss (Pet. Germ., pl. 104, fig. 4) and probably not the *L. aspera* of d'Orbigny (Pal. Franc. pl. 425, figs. 3–6) which is an Upper Chalk form.

LIMA ELONGATA, *Sow.*

1822. Plagiostoma, *Mant.* Foss. South Downs, Tab. 19, fig. 1.
1827. Plagiostoma elongatum, *Sowerby.* Min. Con., pl. 559, fig. 2 (lower figure only).
1841. Plagiostoma elongatum, *Roemer.* Nordd. Kreidegeb., p. 56.
1846. Lima elongata, *Reuss.* Bohm. Kreidef. ii., p. 33, Taf. fig. 6 (not fig. 9).
1847. ?Lima Astieriana, *d'Orbigny.* Pal. Fr., Terr. Crét. iii., pl. 420, f. 4–7.
1850. Lima Reussii, *d'Orbigny.* Prodr. ii., p. 249.
1872. Lima elongata, *Geinitz.* Elbthalg. in Sachsen ii., p. 40, Taf. 9, figs. 9, 10.

Mantell's figure was that of a cast from the Chalk Marl of Hamsey, but in his list of Sussex fossils (Trans. Geol. Soc. Ser. 2, Vol. iii. p. 208) he refers to it and to Sowerby's figure as those of *Plagiostoma elongatum* giving Hamsey and Folkestone as localities.

Sowerby's original description was as follows: "Shell obliquely elliptical, convex, costated; costæ few, distinct, rounded; hinge-line short. The costæ are about 15 or 16, prominent, rounded, and smooth." One of his specimens we take to be *Lima parallela* (see Vol. i. p. 449), and this is in a dark green matrix, which might be that of the *Am. mammillatus* zone or of the *Stauronema* zone at the base of the Chalk Marl. It is stated by Sowerby to have come from the "Upper Greensand" of Folkestone. The other specimen, which we regard as the type of *L. elongata*, came from the Chalk Marl of Hamsey.

We think it most probable that the foreign forms included in the above synonomy are the same species, but until a comparison of specimens with the English type can be made this must remain uncertain. We may, however, remark that many English specimens have about twenty ribs, a variable number of small ribs coming in on each side, and in some specimens the ribs are more or less roughened by small tubercles, such specimens resemble *L. astieriana*, which is described as having twenty-two ribs.

SPONDYLUS LATUS, *Sow.*

1814. Dianchora lata, *Sowerby.* Min. Con., pl. 80, f. 2.
1822. Dianchora obliqua, *Mantell.* Geol. Sussex, p. 206, pl. 25, f. 1, and pl. 26, f. 12.
1834–40. Spondylus lineatus, *Goldfuss.* Pet. Germ. ii., p. 97, Taf. 106, f. 3.
?1872. Sp. latus, *Geinitz.* Elbthalg. in Sachsen, I., p. 187, Taf. 42, figs 4–6 where a full synonomy is given, and II., Taf. 8, figs 18–21.

Geinitz in the last-mentioned work thinks that a comparison of the figures given by Mantell, Dixon, and Goldfuss of the shells known as *B. latus*, *D. obliquus*, and *S. lineatus* will leave little doubt of their all belonging to one species. With this remark one can hardly agree, for Mantell's figures are not good enough to compare with any others, but it may certainly be doubted whether Mantell's *D. obliqua* is more than a variety of Sowerby's *D. lata*. Dixon's figure of *Sp. latus* does not show the upper valve, but Sowerby's figure and description agrees sufficiently with that of Goldfuss' *Sp. lineatus* as to make it very probable that they are the same species; moreover Goldfuss records his *Sp. lineatus* from "the white chalk of Lewes in England." [Since the above was written the above synonomy has been adopted by Mr. H. Woods in his Monograph on British Cretaceous Lamellibranchia.]

The shell was always broadly attached by the lower valve, only a narrow edge generally rising from the surface of attachment; consequently, both valves were greatly dependent on this surface of attachment for the form they took, and great variability is the result.

OSTREA CANALICULATA, *Sow.*

1813. Chama canaliculata, *Sow.* Min. Con., pl. 26, f. 1.
1827. Ostrea lateralis, *Nilsson.* Petrefac. Suecana, 1827, p. 29, pl. 7, fig. 7–10.
1848. Ostrea canaliculata, *d'Orb.* Pal. Fr., Terr. Crét., pl. 471, f. 4–8.
non Ostrea canaliculata, *Sow.* Min. Con., pl. 135.

Sowerby figured in 1813 under the name of *Chama canaliculata* a siliceous shell from the Upper Greensand of Chute, and the same form extends into the lower part of the Chalk.

This shell is known on the Continent as *Ostrea lateralis*, but 't is also generally admitted to be identical with the *Chama canaliculata* of Sowerby. In 1816 (Min. Con., pl. 135) Sowerby descrbed a different shell under the name of *Ostrea canaliculata*, but as they both belong to the genus *Ostrea*, it is clear that the specific name must be applied to the first of them, and consequently Nilsson's name becomes a synonym. It was rightly described by d'Orbigny in 1848 under the name of *Ostrea canaliculata*.

The shell figured by Sowerby in 1816 (Min. Con., pl. 135) is almost certainly identical with that figured by Nilsson in 1827 as *O. lunata*, and as it cannot bear the name of *canaliculata*, Nilsson's name of *O. lunata* is here used

OSTREA LUNATA, *Nilss.*

1816. Ostrea canaliculata, *Sow.* Min. Con., pl. 135, fig. 1.
1827. Ostrea lunata, *Nilss.* Petrefac. Suecana, p. 31, pl. 6, fig. 3.
1834. Ostrea lunata, *Goldf.* Petrefac. Germ., p. 11, pl. 75, fig. 2.
non] Ostrea larva, *d'Orb.* Pal. Fr., Terr. Crét., p. 740, pl. 486, figs. 4–8.

Sowerby in the year 1816 figured a small *Ostrea*, "from the Chalk cliff at Mundesley, near Cromer," under the name of *O. canaliculata* (Min. Con., Pl. 135). This form we are familiar with from the Trimingham Chalk, which belongs to the same zone as that alluded to by Sowerby. Unfortunately, the name had already been used as stated above, and seeing that the form figured as *O. lunata* by both Nilsson and Goldfuss is almost certainly the same species, we adopt that name.

M. H. Coquand (Monog. Genre Ostrea Terr. Crét. 1869, p. 58) has included these forms together with the *O. larva* of Lamarck, Goldfuss and d'Orbigny under Schlotheim's name of *O. ungulata*, and the latter, no doubt, will have priority if M. Coquand's synonymy be correct; but we think there is grave doubt as to the *O. larva* of d'Orbigny and of Goldfuss being the same species as that we here call *O. lunata*, and prefer, therefore, for the present, to keep them distinct.

OSTREA HIPPOPODIUM, *Nilss.*

1827. Ostrea hippopodium, *Nilsson.* Petref. Suecana, p. 30, Taf. 7, f. 1.

1843. Ostrea hippopodium, *d'Orb.* Pal. Fr., Terr. Crét., p. 731, pl. 482.

The forms of *Ostrea* which we refer to this species are of the type shown in the figures above noticed. To enter upon the synonymy of this species would require much time and a large number of continental as well as British specimens. Those who have most closely studied the Cretaceous forms of *Ostrea* are by no means agreed in this matter, as a comparison of the synonymy of this species given by Coquand (Monog. Genre Ostrea Terr. Crét., p. 100 and 146, 1869) and by Geinitz (Elbthalg. in Sachsen i., p. 177, 1871-1875) will show.

OSTREA SEMIPLANA, *Sow.*

1825. Ostrea semiplana, *Sow.* Min. Con., pl. 489, fig. 3.

1833. Ostrea inæquicosta, *Woodw.* Geol. Norfolk, pl. 6, f. 4.

The following are probably referable to the same species:—

1803. Ostracilis sulcatus, *Blum.* Spec. Arch. Tell., pl. 1, fig. 3.

1834. Ostrea flabelliformis, *Goldf.* Petref. Germ., pl. 76, fig. 1.

1843. Ostrea semiplana, *d'Orb.* Pal. Fr., Terr. Crét., pl. 488, fig. 45.

To what extent the synonyms given by Coquand and Geinitz may be correct we are not in a position to determine, but there are some of them with which we cannot agree. The name of *O. sulcatus* was used by Born in 1780 (Cat. Testac., etc., 1780, pl. vii., fig. 3, p. 103), and consequently Blumenbach's use of this same name for an oyster that may be Sowerby's *O. semiplana* cannot be adopted.

O. semiplana occurs in the Middle and Upper Chalk and ranges from the zone of *Terebratulina* to that of *Belemnitella mucronata*.

PECTEN ROBINALDINUS, var. ROTOMAGENSIS, *d'Orb.*

1846. Pecten rhotomagensis, *d'Orbigny.* Pal. Fr., Terr. Cret., p. 609, pl. 436, figs. 9–11.
1847. Pecten subinterstriatus, *d'Arch.* Mem. Soc. Géol. de France, Ser. II., Tom. II. p. 311, pl. 15, f. 10.
1850. Pecten rhotomagensis, *d'Orb.* Prodr. II., p. 169.
1872. Pecten rhotomagensis, *Geinitz.* Elbthalg. in Sachsen, I. p. 196. Taf. 42, f. 20, and Taf. 44, f. 8.

If these species are identical d'Orbigny's name has the priority. D'Orbigny in his " Prodrome " identifies d'Archiac's species with his own, and Geinitz in 1872 accepted this identification. The shells are certainly closely allied, and they occur in beds of the same age; the main difference between the figured specimens consisting in this that *P. subinterstriatus* has oblique striæ plainly visible all over the shell, whereas in *P. rotomagensis* these striæ only occur near the edge of the shell, especially at the sides. A minor difference is that in the former the grooves are fairly straight and regular, in the latter they are very irregular and often disturbed by the concentric lines of growth.

Geinitz' figures agree more closely with that of d'Orbigny than that of d'Archiac. A specimen obtained by Mr. W. Hill from the Cenomanien of La Hève agreed with the types of d'Orbigny and Geinitz, while most of those from the Cenomanian of Devon and from the highest part of our Upper Greensand more resemble the *P. subinterstriatus* of d'Archiac. Some, however, from Devon are unquestionably like *P. rotomagensis.*

We agree with Mr. Woods in thinking that this form is only a variety of the very variable species for which he adopts the name of *P. robinaldinus,* d'Orb.

UNICARDIUM RINGMERIENSE *Mant.*

1822. Venus? Ringmeriensis, *Mantell.* Geol. Sussex, p. 126, pl. 25, f. 5.
1840. Cucullæa Rœmeri, *Geinitz.* Charact. der Sch. II. p. 50, Taf. 10, f. 10, 11; Taf. 20, f. 15.
1846. Arca (Cucullæa) Rœmeri, *Reuss.* Bohm. Kreidef. II. p. 13, Taf. 34, figs. 41, 42.
1850. Arca Rœmeri, *d'Orbigny.* Prodr., p. 244.
1854. Unicardium Ringmeriense, *Morris.* Cat. Brit. Foss., p. 229.
1864. Fimbria coarctata, *Zittel.* Bivalven der Gosaugeb., p. 45, Taf. 7, f. 5.
1872 ?Mutiella Ringmerensis, *Geinitz.* Elbthalg. in Sachsen II. p. 61, Taf. 16, figs. 11–13.

This shell is generally known in England under the name of *Unicardium ringmeriense,* but the above synonymy will show that it has been referred to several genera. The adult form was first described and figured by Mantell, but has never been figured in England since. The German synonymy is taken from Geinitz, who in 1872 identified his *Cucullœa Rœmeri* with Mantell's shell. giving at the same time three good figures of different-sized specimens.

Geinitz regarded the *Corbis rotundata* of d'Orbigny as the same species, but so far as we can judge from casts of *C. rotundata* from the Cenomanian of France, Geinitz is mistaken in this supposition.

The genus *Mutiella* was founded in 1870 by Stoliczka (Cret. Fauna of S. India, III., p. 248).

Echinodermata.

PSEUDODIADEMA BRONGNIARTI, *Ag.*

1840. Tetragramma Brongniarti, *Ag.* Desc. d. Ech. foss. de la Suisse. Tome ii. p. 25, pl. 14, fig. 4–6.
1856. Diadema Brongniarti, *S. P. Woodward.* Mem. Geol. Surv. Dec. 5, pl. 2, p. 9.
1868. Pseudodiadema Brongniarti, *Wright.* Pal. Soc., Brit. Foss. Echin. Cret. pl. 21A, fig. 2 (Woodward's type).
non *Wright.* Loc. cit. pl. 20, fig. 2 nec pl. 21B, fig. 3.

Dr. S. P. Woodward referred an Echinoderm in the British Museum, from the Chalk Marl of Dover to *Diadema Brongniarti*, Ag., and Dr. Wright figured the same specimen in his monograph of the Cretaceous Echinodermata (pl. 21A, fig. 2). The close resemblance which this species bears to *P. variolare* is generally acknowledged, and we have doubted the occurrence of the true *P. Brongniarti* in this country; but Dr. S. P. Woodward's type has the ambulacra in single pairs from the mouth to the ambitus and thence bigeminal to the highest part of the test. It thus differs from *P. variolare* in which the ambulacra are trigeminal around the mouth and bi- or tri-geminal above. The higher test of *P. Brongniarti* is a character not easy to appreciate when comparing variable urchins. For the above reasons we follow Dr. Woodward in accepting *P. Brongniarti* as occurring in the Chalk Marl of Dover; but we are unable to accept any other of Dr. Wright's figures as referable to this species.

They do not agree with the figures or the description given by Agassiz, nor do they agree with two examples of the true *Ps. Brongniarti* kindly sent to one of us by M. Loriol-Lefort.* Agassiz says that *Ps. Brongniarti* resembles *Ps. variolare*, but is more inflated and less depressed; the rows of secondary tubercles are much less apparent, the base of the tubercles is large and the mamelon small; the pores are in single pairs. To which we may add that in *Ps. Brongniarti* the principal rows of tubercles, *i.e.*, two on the ambulacral and four on the interambulacral areas are nearly equidistant from each other, imparting a very regular appearance to the test.

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* These specimens are now in the British Museum at South Kensington.

PSEUDODIADEMA MACKIEI, *S. P. Woodw.*

1856. Diadema Mackiei, *S. P. Woodward.* Mem. Geol. Survey, Dec. 5, pl. 2, p. 9.
1868. Pseudodiadema Brongniarti, *Wright.* Pal. Soc. Brit. Foss. Echin. Cret., pl. 20, fig. 2, and pl. 21B, fig. 3.

In 1856, Dr. S. P. Woodward described a new series under the name of *Diadema Mackiei* in the following terms: "Inflated depressed; lat. 24 lines; oral opening deeply sunk, lat. 6 lines; apical opening pentagonal, 7½ lines; ambulacral pores crowded above; primary tubercles not diminishing sensibly above but decreasing regularly below; ambulacral tubercles in two rows of seventeen each, at wide intervals above, the rows separated by a continuous granulated space; interambulacral tubercles in six principal rows, bordered at the circumference by accessory rows, the central space wide, granulated and tuberculated, becoming bare and channelled above. Spines slender, solid, finely striated. Locality, Grey Chalk, Dover (Coll. S. J. Mackie and Bowerbank)."

He also states that a specimen in Mr. Bowerbank's collection measures 2½ inches across.

Dr. Wright in the Palæont. Society's monograph does not refer to this species, but some of the specimens which he refers to *Ps. Brongniarti* on Plates 20 and 21B agree very closely with the description of *Ps. Mackiei*, and differ greatly from the true *Ps. Brongniarti* which we have already described. Specimens agreeing with these figures and with Woodward's description are not uncommon in the Chloritic Marl, in the nodule bed at the base of the Chalk near Chard, and in other parts of the Lower Chalk. We are disposed therefore to regard them as referable to *Ps. Mackiei* and not to *Ps. Brongniarti.*

CIDARIS SORIGNETI, *Desor.*

1858 Cidaris Sorigneti, *Desor.* Syn. d. Echin, foss. p. 446, pl. 6, fig. 16.
1862–67. Cidaris Sorigneti, *Cotteau.* Pal. Fr., Terr. Crét., Tome vii., p. 237, pl. 1050, fig. 9–14.
1871. Cidaris Sorigneti, *Geinitz.* Elbthalg. in Sachsen, p. 68. pl. 15, fig. 1–19.

This species is a near relation of *Cidaris clavigera*, and it is probable that its spines have hitherto been referred to *C. clavigera* by English collectors, but we have obtained many spines and part of a test from the Middle Chalk of the Devonshire coast which show certain marked differences from *C. clavigera* and agree with the figures of *C. Sorigneti.*

The test resembles that of *C. clavigera* and the ambulacral areas are very narrow with four rows of granules, the outer rows being much larger than the two inner rows, the granules of which are placed alternately. The interambulacral areas are very wide, with five or six tubercles in each row, the tubercles are prominent and imperforate, but not large, each is surrounded by a narrow areola, the margin of which is bordered by a ring of large granules; the miliary zone is wide and studded with large granules, but these are fewer in number than in a typical *C. clavigera*.

The spines are broadly clavate, stumpy, and very short in the shank, which is less than a third of the total length; the clavate head is generally oval, pointed at the top, ornamented with regular prominent spiny ribs. These spines differ from those of *C. clavigera* in the length of the shank, in their pointed top and more prickly ribs; the spines of *C. clavigera* being rounded at the top and usually (but not always) having a shank as long or longer than the head.

HOLASTER PLANUS, *Mantell*.

1822. Spatangus planus, *Mant.* Geol. of Sussex, p. 192, pl. 17, Figs. 9 and 21.
1829. Spatangus planus, *Phillips.* Geol. of Yorkshire, pl. 1, fig. 15.
1849–50. Holaster planus, *Geinitz.* Quad. Deutsch. p. 226.
1853. Holaster planus, *d'Orb.* Pal. Fr. Ter. Crét. vi., p. 116, pl. 821.
1870. Holaster planus, *Roemer.* Geol. v. Oberschlesien p. 312. Taf. 37, f. 1 2.
1872. Holaster planus, *Geinitz,* Elbthalgeb. in Sachsen, p. 9, Taf. 3, figs. 2 and 3 (eight views).
1881. Holaster planus, *Gosselet.* Esquisse Geol. du Nord, Tom. II. pl. 21, fig. 10.
1881. Holaster lævis var. planus, *Wright.* Pal. Soc., Brit. Foss. Echin. Cret. pl. 79, fig. 1a, b.
Non Holaster lævis var. planus, *Wright.* Op. cit., p. 317, and pl. 62, fig. 2.

Holaster planus is not a large urchin, its full size being usually $1\frac{1}{2}$ to $1\frac{3}{4}$ inches in length; it has an oval outline when viewed from above, a rounded and inflated cross outline when seen from front or rear. The test is thin and covered with sparsely and irregularly scattered tubercles; the base is convex and the margins rounded, not a flat base with a sharp edge as in *Holaster nodulosus* and *H. trecensis.* In well preserved examples a fasciole may be traced around the ambitus. The periprocte is situated in a slight depression about half way up the posterior of the test, a character by which it is easily distinguished from other species.

Hol. planus was well described and figured by Geinitz in his Elbthalgebirge in Sachsen (1872), except that his specimens seem less convex beneath than most English examples. This species is specially characteristic of the lowest part of the Upper Chalk, but is found also in the uppermost part of the Middle Chalk: it has never been found below the *Terebratulina* zone and is rare in the *Micraster cortestudinarium* zone.

The form described by Wright as *H. planus* is not this species but a variety of *H. lævis* or *H. nodulosus.* The specimens figured on his Pl. 79 are, however, the true H. planus.

HOLASTER PLACENTA, *Ag.*

1840. Holaster placenta, *Agassiz.* Cat. Syst. Ectyp. Echinod. Mus. Neocom., p. 133, and Cat. Raisonné, p. 2.

1849–56. Holaster placenta, *Cotteau.* Echinides Foss. du dep. de l'Yonne, p. 486, pl. 82, fig. 3.

Cotteau was the first to give a figure of this species, and his description is as follows: "Testâ maximâ, oblongâ, inflatâ, supernè depressâ, infernè planâ, antice rotundatâ, vix emarginatâ. Vertice subantico. Zonis ambulacrariis strictis, ferè equalibus, anterioribus paribus subrectis. Testâ tenuissimâ et fragili."

Height, 40 mm. Width, 86 mm. Length, 91. Horizon, chalk with *Micraster cortestudinarium.*

This species has been known for many years in France and has been recognised by French geologists in English Chalk* ; but it is only recently that its existence has been admitted by English geologists, and notably by Dr. A. Rowe, of Margate, and Major-General Cockburn of Dover. Dr. Rowe† has shown that it ranges from the zone of *Rhynchonella Cuvieri* to that of *Actinocamax quadratus,* though it is commonest in those of *H. planus* and *Micr. cortestudinarium.*

This species is easily distinguished from *H. planus* by its flattened under surface, by the low position of the periprocte and by its general larger size. It much resembles *Holaster trecensis,* but can be distinguished by the thinness of the test, a character in which it resembles *H. planus.*

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* By Hébert, near Dover, see Bull. Soc. Géol. de France, Ser. 3, Tom. ii. p. 424 (1874), and by Barrois in Hampshire, Recherches sur le terr. crét., Sup. p. 41 (1876).

† The zones of the White Chalk, &c. Proc. Geol. Assoc., Vol. xvi. p. 289. (1900).

B.—GENERAL LIST OF FOSSILS FROM THE CHALK OF ENGLAND.

The following catalogue of the fossils from the Chalk of England has been compiled principally from the lists given in the text of this memoir, and the sources from which these lists have been derived have been acknowledged in each case.

The old collections of Chalk fossils which exist in many museums are of little stratigraphical value because in so many cases the horizons and localities from which the specimens came have not been preserved with sufficient accuracy. Now that the zonal method is acknowledged to be the only way in which the stratigraphy of the Chalk formation can be studied with any hope of success, it is essential that the precise "gisement" of every fossil should be properly recorded by the finder if his fossils are to be made of scientific value. Either he must determine the zone from which each specimen came or he must record the exact quarry and level in the quarry (if a large one) where the fossil was found.

For want of such information many species appear in the following catalogue without any indication of the zone in which they occur. We hope that some of our readers will be able to fill in these blanks during the course of their further collecting, and any such information will be gratefully received either by the author or by the Director.

Besides the fossils collected by the author and Mr. Hill, and by Mr. Rhodes under their superintendence, in the areas which were surveyed or examined for the purposes of this memoir, the following sources of information may be mentioned :—

1. The lists given by Prof. Barrois in his Researches on the Chalk of England, and the Index to these published by Mr. E. Westlake.
2. The lists published in various papers by Mr. W. Hill and the author.
3. The lists published by Dr. A. W. Rowe in his recent papers on the White Chalk of the English coast (Proc. Geol. Assoc., Vol. xvi. p. 289 and Vol. xvii. p. 71).
4. The lists in the papers by Mr. H. Woods on the Fauna of the Chalk-Rock (Quart. Journ. Geol. Soc., Vols. lii. and liii., 1896–1897.).
5. Unpublished lists, kindly placed at our disposal by Dr. H. P. Blackmore, of fossils collected by him from the several zones of the Chalk near Salisbury.
6. Unpublished lists of fossils, carefully collected from various parts of Hampshire, and from the Isle of Wight by Messrs. Ch. Griffith and R. M. Brydone, and kindly communicated by them.
7. A list of fossils found in the Upper Chalk of Yorkshire, for which we are indebted to Mr. Stather of Hull.

With respect to nomenclature :—

Mr. E. T. Newton has revised the lists of Reptiles and Fishes. The fourth volume of the Catalogue of Fossil Fishes in the British Museum was published after this list was in type, and thus we have not been able to take full advantage of Dr. Smith Woodward's valuable work.

The species of Nautilus have been named, in accordance with the British Museum Catalogue of Cephalopoda, by Messrs. Foord and Crick.

The Bryozoa have been revised with the assistance of the British Museum Catalogue by Dr. J. W. Gregory.

The list of Entomostraca is based on that given by Messrs. Jones and Hinde in their Monograph in the Palæont. Soc., volume for 1889, supplemented zonally by Mr. Chapman's identifications of species obtained by Mr. W. Hill in the course of washing many samples of chalk.

The list of Foraminifera is chiefly due to the labours of Mr. F. Chapman, who has not only published lists of the species found at Taplow, Lewes, and Swancombe, but has identified all the species isolated by Mr. Hill in the course of his microscopical work (see p. 349).

The list of Sponges is based on the British Museum Catalogue by Dr. G. J. Hinde, who has also been kind enough to identify many specimens sent to him from time to time.

The following list is designed to show the zonal range of the species, so far as existing information allows, but it must be remembered that our present knowledge is very imperfect, and that many of the species may have a longer range than is indicated in these columns. There are also gaps which will doubtless be filled up by those who continue to collect carefully from the zones of the Chalk.

Besides the zonal arrangement some indication of geographical distribution has been attempted, the method adopted being the same as in the first volume of this memoir. Thus the reader using this list will be able to see at once in what zones any given species has been found, and also from what parts of the country it has been obtained.

The following is an index to the contractions used :—

Be = Berkshire
Bd = Bedfordshire.
Bk = Buckinghamshire.
Cam = Cambridgeshire.
Ch = Chard and Chardstock.
Ct = Charlton (Kent).
De = Devizes.
Dev = Devonshire.
Do = Dover.
Dor = Dorsetshire.
E = Eastbourne.
Es = Essex.
EK = East Kent.
F = Folkestone.
Ha = Hampshire.
He = Hertfordshire.
Hun = Hunstanton.
IW = Isle of Wight.
LC = Lower Chalk.
Lin = Lincolnshire.
Mar = Margate.
MC = Middle Chalk.
Mid = Middlesex.
MB = Maiden Bradley (Wilts.)
Nor = Norfolk.
ND = North Dorset.
NW = North Wiltshire.
Ox = Oxfordshire.
Sal = Salisbury.
Suf = Suffolk.
Sur = Surrey.
Sus = Sussex.
SD = South Dorset.
Sp = Speeton.
Tr = Trimmingham.
UC = Upper Chalk.
WD = West Dorset.
WK = West Kent.
Yo = Yorkshire.

SPECIES.	* Found in Selbornian.	Lower Chalk.					Middle Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	*	Chloritic Marl (Stauronema) 1	Devon Cenomanian &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
REPTILIA.																
Ornithosauria.																
Ornithocheirus Carteri, *Seeley*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
" compressirostris, *Owen*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Burham (*Pterodactylus*).
" Cuvieri, *Bowerb.*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Burham and Halling.
" diomedius, *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(*Cimoliornis*, Owen) Mid. C., Kent.
" giganteus, *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Burham (*Pterodactylus*).
" Fittoni, *Owen* -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	(*Pterodactylus*)1 Cam.
" sp. - - - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MC. and LC. Kent (*Lydekker*).
Cimoliornis diomedius, Owen (*see* Ornithocheirus giganteus).																
Dinosauria.																
Acanthopholis eucercus, *Seeley*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
" horridus, *Huxley*	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Folkestone. 1 ? Cam.
" stereocercus, *Seeley*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Anoplosaurus curtonotus, *Seeley*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Anoplosaurus major, *Seeley*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Iguanodon Hilli, *Newton* -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Arlesey (T.S.).
Macrurosaurus semnus, *Seeley*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Trachodon cantabrigiensis, *Lyd.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Squamata.																
Acrodontosaurus Gardneri, Hulke (*see* Pachyrhizodus, Pisces).																
Liodon anceps - - - -	-	-	-	-	-	-	-	-	-	-	10	-	12	13	-	10 Sal. 12 Sal. 11 Mar. 13 Nor.
Mosasaurus Camperi, *Meyer*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(= M. Hoffmanni.)
" *stenodon, Charl.* (*see* Liodon anceps).																
" gracilis *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
" sp. - - -	-	-	-	-	-	-	-	-	-	-	10	11	-	-	-	UC. Gravesend and Ramsgate.
Coniasaurus crassidens, *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Washington and near Charing.
Dolichosaurus longicollis, *Owen*	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 Burham, Lydden Spout.
Raphiosaurus subulidens, *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Cambridge.
Saurospondylus dissimilis, *Seeley*	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 Cam.
Ichthyopterygia.																
Ichthyosaurus campylodon *Carter*	- *	1	-	3	4	-	-	-	-	-	-	-	-		-	1 Cam, E. 3 E, F, Bd Cam. 4 Do.

With respect to nomenclature :—

Mr. E. T. Newton has revised the lists of Reptiles and Fishes. The fourth volume of the Catalogue of Fossil Fishes in the British Museum was published after this list was in type, and thus we have not been able to take full advantage of Dr. Smith Woodward's valuable work.

The species of Nautilus have been named, in accordance with the British Museum Catalogue of Cephalopoda, by Messrs. Foord and Crick.

The Bryozoa have been revised with the assistance of the British Museum Catalogue by Dr. J. W. Gregory.

The list of Entomostraca is based on that given by Messrs. Jones and Hinde in their Monograph in the Palæont. Soc., volume for 1889, supplemented zonally by Mr. Chapman's identifications of species obtained by Mr. W. Hill in the course of washing many samples of chalk.

The list of Foraminifera is chiefly due to the labours of Mr. F. Chapman, who has not only published lists of the species found at Taplow, Lewes, and Swancombe, but has identified all the species isolated by Mr. Hill in the course of his microscopical work (see p. 349).

The list of Sponges is based on the British Museum Catalogue by Dr. G. J. Hinde, who has also been kind enough to identify many specimens sent to him from time to time.

The following list is designed to show the zonal range of the species, so far as existing information allows, but it must be remembered that our present knowledge is very imperfect, and that many of the species may have a longer range than is indicated in these columns. There are also gaps which will doubtless be filled up by those who continue to collect carefully from the zones of the Chalk.

Besides the zonal arrangement some indication of geographical distribution has been attempted, the method adopted being the same as in the first volume of this memoir. Thus the reader using this list will be able to see at once in what zones any given species has been found, and also from what parts of the country it has been obtained.

The following is an index to the contractions used :—

Be = Berkshire
Bd = Bedfordshire.
Bk = Buckinghamshire.
Cam = Cambridgeshire.
Ch = Chard and Chardstock.
Ct = Charlton (Kent).
De = Devizes.
Dev = Devonshire.
Do = Dover.
Dor = Dorsetshire.
E = Eastbourne.
Es = Essex.
EK = East Kent.
F = Folkestone.
Ha = Hampshire.
He = Hertfordshire.
Hun = Hunstanton.
IW = Isle of Wight.
LC = Lower Chalk.
Lin = Lincolnshire.

Mar = Margate.
MC = Middle Chalk.
Mid = Middlesex.
MB = Maiden Bradley (Wilts.)
Nor = Norfolk.
ND = North Dorset.
NW = North Wiltshire.
Ox = Oxfordshire.
Sal = Salisbury.
Suf = Suffolk.
Sur = Surrey.
Sus = Sussex.
SD = South Dorset.
Sp = Speeton.
Tr = Trimmingham.
UC = Upper Chalk.
WD = West Dorset.
WK = West Kent.
Yo = Yorkshire.

SPECIES.	* Found in Selbornian.	Lower Chalk.					Middle Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	*	Chloritic Marl (Stauroneuma) 1	Devon Cenomanian &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
REPTILIA.																
Ornithosauria.																
Ornithocheirus Carteri, *Seeley*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
„ compressirostris, *Owen*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Burham (*Pterodactylus*).
„ Cuvieri, *Bowerb.*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Burham and Halling.
„ diomedius, *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(*Cimoliornis*, Owen) Mid. C., Kent.
„ giganteus, *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Burham (*Pterodactylus*).
„ Fittoni, *Owen* -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	(*Pterodactylus*)1 Cam.
„ sp. - - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MC. and LC. Kent (*Lydekker*).
Cimoliornis diomedius, Owen (*see* Ornithocheirus giganteus).																
Dinosauria.																
Acanthopholis eucercus, *Seeley*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
„ horridus, *Huxley*	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Folkestone. 1 ? Cam.
„ stereocercus, *Seeley*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Anoplosaurus curtonotus, *Seeley*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Anoplosaurus major, *Seeley*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Iguanodon Hilli, *Newton* -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Arlesey (T.S.).
Macrurosaurus semnus, *Seeley*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Trachodon cantabrigiensis, *Lyd.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Squamata.																
Acrodontosaurus Gardneri, Hulke (*see* Pachyrhizodus, Pisces).																
Liodon anceps - - -	-	-	-	-	-	-	-	-	-	-	10	-	12	13	-	10 Sal. 12 Sal. 11 Mar. 13 Nor.
Mosasaurus Camperi, *Meyer*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(= M. Hoffmanni.)
„ *stenodon, Charl.* (*see* Liodon anceps).																
„ gracilis *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
„ sp. - - -	-	-	-	-	-	-	-	-	-	-	10	11	-	-	-	UC. Gravesend and Ramsgate.
Coniasaurus crassidens, *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Washington and near Charing.
Dolichosaurus longicollis, *Owen*	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 Burham, Lydden Spout.
Raphiosaurus subulidens, *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Cambridge.
Saurospondylus dissimilis, *Seeley*	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 Cam.
Ichthyopterygia.																
Ichthyosaurus campylodon *Carter*	- *	1	-	3	4	-	-	-	-	-	-	-	-		-	1 Cam, E. 3 E, F, Bd Cam. 4 Do.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
REPTILIA—Cont.																
Sauropterygia.																
Cimoliosaurus Bernardi, *Owen*	*	1	-	-	-	-	-	7	-	-	-	-	-	-	-	(Plesiosaurus) 1 Cam 7 Sus.
„ constrictus, *Owen*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(Plesiosaurus) Steyning.
„ Smithi, *Owen* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(Plesiosaurus) MC Burham.
„ planus, *Owen* -	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	(Plesiosaurus) 1 Cam.
„ *pachycnemus, Owen* (see planus)																
„ sp. - - -	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11 Sal. 12 Sal.
Polyptychodon interruptus, *Owen*	*	1	-	3	-	-	-	7	8	-	-	-	-	-	-	1 Cam, E. 3 E, F. 4 He, Cam. 7 Arundel. 8 Do.
Chelonia.																
Emys sp. - - - -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam (Seeley).
Testudo sp. - -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam (Seeley).
Chelone (*see* Cimoliochelys).																
Chelonian bones - - -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam, LC, Glynde.
Cimoliochelys Benstedi, *Owen*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	LC. Burham, MC., Kent. 9 WK.
„ Camperi, *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?=Hoffmanni, LC. Burham.
„ sp. . - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Dover, UC. Rochester.
Lytoloma cantabrigiense, *Lyd.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
„ sp. - -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam, MC, Halling.
Rhinochelys sp. - - -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Dover, LC. near Lewes.
Protostega anglica, *Lyd.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Chalk of Lewes & Dorking.
PISCES.																
1.—*Elasmobranchii.*																
Acrodus cretaceus, Dixon (*see* Cestracion canaliculatus).																
Acrodus Illingsworthi, *Ag.*	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 S s.
„ transversus?, *Ag.* -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Cantioscyllium decipiens, *A. S. Woodw.*	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	6? Burham.
Cestracion canaliculatus, *Eg*	*	1	-	3	-	-	-	-	-	-	-	-	12	-	-	1 Cam. 3 Sus 12 Sal.
„ rugosus, *Ag.* -	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 WK.
„ sulcatus, *Ag.* -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 near Maidstone.
Corax affinis, *Ag.* - - -	-	-	-	-	-	-	-	-	-	-	10	11	-	13	-	10 Sal. 11 Mar. 13 Nor.
„ falcatus, *Ag.* (=*heterodon*, Reuss).	*	1	-	3	4	5	6	7	8	9	10	11	12	13	-	1 Cam. 3 Sus, F. 4 E. Ha, Bk, Cam. 5 F. 6 Ha, Dev. 7 Common. 8 IW, Bd, He. 9 to 11 common. 12 Sal, Sus. 13 Sal, Do. Nor.

SPECIES.		Lower Chalk.					Midl'e Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
PISCES—Cont.																
Elasmobranchii—Cont.																
Corax maximus, *Dixon* -	-	-	-	-	-	-	-	-	-	-	-	-	12	13	-	12 Sal. 13 Nor.
„ pristodontus, *Ag.* -	*	-	-	-	-	-	6	-	-	-	10	11	12	13	-	6 Ha. 10 EK. 11 Ha, Mar. 12 Sus. 13 Nor.
Drepanephorus (*see* Cestracion).																
Galeocerdo Jaekeli. *A. S. Woodw.*	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11 Sal. 12 Sal.
Gomphodus sp. - - -	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	? 10 Charing.
Hybodus (*see* Synechodus).																
Lamna *acuminata*, *Ag.* (*see* Oxyrhina Mantelli).																
„ appendiculata, *Ag.*	*	1	2	3	4	5	6	7	8	9	10	11	12	13	-	Common throughout.
„ arcuata, *A.S.W.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ macrorhiza, *Cope* -	*	1	-	-	4	5	-	-	-	-	10	11	12	13	-	(= L. gracilis, P. & C.). 1 Cam. 4 Bk, He, Cam. 5 He. 10 WK, Sal. 11 Sal. 12 Sal. 13 Nor.
„ *raphiodon*, *Ag.* (*see* Scapanorhynchus).																
„ semiplicata, *Ag.* -	-	-	-	-	-	-	-	-	-	9 ?	10	-	-	-	-	? 9 Rochester 10 Ha.
„ serra, *A. S. Woodw.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
„ *subulata*, *Ag.* (*see* Scapanorhynchus).																
„ sulcata, *Gein.* - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Dover. Also Chalk of Sussex and Surrey.
„ *plicatella*, *Reuss* (*see* Scapanorhynchus raphiodon).																
Notidanus microdon, *Ag.* -	*	1	-	3	4	-	6	7	-	9	10	11	12	13	-	1 E, Cam 3 F, Sus. 4 E, WK, Bd, Cam. 6 Sus. 7 Sus. 9 WK. 10 EK, WK. 11 Sal, Sur, EK. 12 Sal. 13 Nor.
„ *pectinatus* (see N. microdon).																
„ sp. (large) - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14 Tr.
Odontaspis gracilis, *P. and C* (*see* Lamna macrorhiza).																
Otodus (*see* Lamna).																
Oxyrhina angustidens, *Reuss*	*	-	-	3	4	-	-	-	-	-	10	-	-	13	-	3 Sus. 4 WK. 10 WK. 13 Nor.
„ *heteromorpha*, *Reuss* (*see* angustidens).																
„ crassidens, *Dixon*	-	-	-	-	-	-	6	7	-	9	10	-	12	-	-	6 Sus. 7 Sus. 9 Sus. 10 Ha. 12 Sal.
„ Mantelli *Ag.* -	*	1	2	3	4	-	6	7	8	9	10	11	12	13	14	1 Cam. 3 F. Sus. 4 Ha, Cam, Bd. 6 Ha. 7 Do, Ha, Sus. 8 Ha. He. common from 9 to 12. 13 Nor. 14 Tr.
Ptychodus decurrens, *Ag.* (incl. P. depressus, *Dix.*).	*	-	2	3	4	5	6	7	-	9	10	-	12	13	-	Common in 3 to 7. 9 WK. 10 WK. 12 Sal.
„ latissimus, *Ag.* -	*	-	-	3	-	-	-	7	8	-	10	-	-	-	-	7 He. 8 Bd. 10 WK, Ha.
„ levis, *A.S W.* -	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 Dover & Burham.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
PISCES.—Cont.																
Elasmobranchii—Cont.																
Ptychodus mammillaris, *Ag.*	?	-	-	3	4	5	6	7	8	9	10	-	-	13	-	Common in 4 to 9. 10 Sus, Ha. 13 Nor.
„ mammillaris var. altior, *Ag.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 WK.
„ Mortoni, *Mant.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Chalk of Winchester.
„ Oweni, *Dixon*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Sus.
„ *paucisulcatus*, *Dix.* (*see* latissimus).																
„ polygyrus, *Ag.*	-	-	-	-	4	5	6	7	-	9	10	11	-	-	-	4 WK, Sur, Ha, Cam. 5 F. 6 Do. 7 Do, Ha. 8 Do. 9 WK, Do. 10 WK, Sal, Ha. 11 ND, Sal.
„ rugosus, *Dixon*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Sur. 10 Sur, WK.
„ sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
Scapanorhynchus raphiodon, *Ag.*	*	1	-	3	4	-	6	7	8	-	10	11	12	13	-	1 E, IW. 4 Ha. 6 Dev. 7 Ha. 8 Es. 10 Ha, Sal. 11 Sal, Yo. 12 Sal. 13 Nor.
„ subulatus, *Ag*	*	1	-	3	4	-	6	7	-	-	10	11	12	13	14	1 Cam. 3 F, E. 4 Bk, Bd, Cam. 6 Do. 7 Sus. 10 Sur, WK, EK. 11 Mar. 12 Sal. 13 Nor. 14 Tr.
„ gigas	*	1	-	-	-	-	-	-	-	-	10	-	-	-	-	1 Cam. 10 WK.
„ sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
Scylliodus antiquus, *Ag.*	-	-	-	-	-	-	-	-	-	-	10	11	12	-	-	10 Sal. 11 Sal. 12 Sal.
Sphenonchus sp. (defence)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Squatina Cranei, *A.S.W.*	-	-	-	?3	-	-	-	-	-	-	-	-	-	-	-	L C. Clayton (Sussex).
„ sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U Ch. (Sussex).
Synechodus dubrisiensis, *Mackie*	*	-	-	-	-	-	-	-	-	-	-	-	12	-	-	Ch. of Sussex.
„ sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ sp. (dorsal spine)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
2.—*Chimæroidei.*																
Cœlorhynchus cretaceus, *Dixon*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus.
Edaphodon Agassizi, *Buckl.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus. (Hamsey & Clayton).
„ crassus, *Newton*	*	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 WK. (Charlton).
„ gigas, *Ag.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus.
„ Mantelli, *Buckl.*	*	1	-	3	4	-	-	-	-	-	10	-	-	-	-	1 E. 3 Sus. 4 WK. 10 WK.
„ Reedi, *Newton*	*	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 Sus. (Glynde).
„ Sedgwicki, *Ag.*	*	1	-	3	-	-	-	-	-	-	-	-	-	13	-	1 Cam. 3 Lewes. 13 Nor.
Elasmodectes Willetti, *Newton*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3 F, Sus.
Ischyodus *brevirostris*, *Ag.* (*see* I. Thurmanni).																
„ incisus, *Newton*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Sus, Burham.
„ planus, *Newton*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ Thurmanni, *P. & C.*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	"Chalk of Sussex."

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian. *	Chloritic Marl (Stauronema) 1	2 Devon Cenomanian, &c. 2	3 Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
PISCES—Cont.																
3.—*Teleostomi.* (a. Ganoids.)																
Acrotemnus faba, *Ag.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Chalk of Sussex.
Anomœodus angustus, *Ag.*	*	1	–	–	–	–	–	–	–	9	10	11	–	–	–	1 MB. 9 Sus. 10 WK. 11 Mar.
„ *cretaceus, Ag.* (*see* A. angustus).																
„ Willetti, *A.S.W.*	–	–	–	–	?4	–	–	–	–	–	–	–	–	–	–	LC. Glynde, Sussex.
Ancistrodon sp.	–	–	–	–	–	–	–	–	–	–	10	11	12	13	–	10 to 13 Sal.
Belomnostomus attenuatus, *Dixon.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Chalk of Sussex.
„ cinctus, *Ag.*	–	–	–	–	–	–	–	7	–	–	–	11	–	–	–	7 Ha. 11 or 12 "Brighton." 11 Mar.
Caturus? similis, *Ag.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Sussex and Kent.
Cœlodus *angustus, Ag.* (*see* Anomœodus).																
„ *faba, Ag.* (*see* Acrotemnus).																
„ fimbriatus, *A.S.W.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	LC. Halling.
„ parallelus, *Dixon*	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Chalk of Sussex.
Gyrodus *angustus, Ag.* (*see* Anomœodus).																
„ cretaceus, *Ag.*	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	Chalk Lewes & 6 Ha.
Lophiostomus Dixoni, *Fg.*	–	–	–	c	–	–	–	–	–	–	–	–	–	–	–	Sus (Alfriston).
Macropoma Mantelli, *Ag.*	–	–	–	3	4	–	6	7	8	–	10	11	12	–	–	Common in 3 & 4. 6 Ha. 7 Do, Ha. 8 WK. 10 EK. Sus. 11 Mar. Sus. 12 Sus.
„ sp.	–	–	–	–	–	–	–	–	–	–	·	–	12	–	–	12 Ha.
Neorhombolepis excelsus, *A.S.W.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	LC. Halling (Kent).
Phacodus punctatus, *Dixon*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Chalk of Lewes (indeterminable).
Pisodus?	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F.
Pycnodus *marginalis, Ag.* (*see* Gyrodus cretaceus).																
„ *parallelus, Dix.* (*see* Cœlodus).																
(b. Teleosteans.)																
Acrognathus boops, *Ag.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	UC. Kent and Sur.
Aipichthys nuchalis, *Eg.* (*in Dixon*)	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 Sus.
Apateodus striatus, *Ag.*	–	–	–	3	4	–	–	7	–	9	–	–	–	–	–	4 Sur, Cam. 7 WK.
„ lanceolatus, *A.S.W.*	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	4 Do.
Aulolepis typus, *Ag.*	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	? 4 Burham (Kent), UC. Dorking.
Berycopsis elegans, *Dixon*	–	–	–	3	4	–	–	7	–	–	–	–	–	–	–	3 Sus. 4 Burham, 7 or 8 WK.
Berycopsis major, *A.S.W.*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Cuxton, Kent.
„ pulchella, *A.S.W.*	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 Do.
Beryx microcephalus, (*see* Ctenothrissa).																
„ *ornatus* (*see* Hoplopteryx lewesiensis).																
„ *radians,* (*see* Ctenothrissa).																

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema.) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
PISCES—Cont.																
Teleostomi—Cont.																
Beryx superbus (*see* Hoplopteryx).																
Calamopleurus anglicus, (*see* Syllæmus.)																
Cimolichthys lewesiensis, *Mant.*	-	-	-	3	4	-	-	7	-	9	10	11	12	13	14	3 WK. 4 Do. Sus, Ha, Nor. 7 Sur. 9 WK. 10 EK, Ha, Sus, Suf, 11 Mar, Sal. 12 Sal. 13 Sal, Nor. 14 Tr.
„ striatus, *Ag.* (?=Apateodus)	*	-	-	3	4	5	-	-	-	9	-	-	-	-	-	3 Sus. 4 Bd, Cam. 5 Cam. 9 WK.
Cladocyclus lewesiensis. *Ag.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Sur.
Ctenothrissa microcephala, *Ag.*	-	-	-	3	4	-	-	-	-	-	10	11	-	-	-	3 Sus. 4 WK. 10 WK. 11 Mar.
„ radians, *Ag.* -	-	-	-	3	4	-	6	7	8	9	10	11	12	-	-	3 Sus. 4 Sus, He. 6 Sus. 7 Ha, Sus. 8 to 12 Sus.
Daptinus (*see* Saurodon).																
Dercetis (*see* Leptotrachelus)																
Elopopsis crassus, *Dixon* -	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	7? Sus (Malling).
Enchelurus anglicus, *A.S.W*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Kent.
Enchodus lewesiensis, *Mant.* (= E. halocyon, *Ag.*)	*	1	-	3	-	5	-	7	8	9	10	11	12	13	14	1 Cam. 3 Sus. 5 SD. 7 Sus. 8 IW. 9 WK. 10 to 12 Common. 14 Tr.
„ *annectens A.S.W.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Chalk, Kent.
„ *pulchellus A.S.W.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Chalk, Kent and Sus.
„ serratus? *Eg.* -	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11 Sal. 12 Sal.
Halec eupterygius, *Dixon* -	-	-	-	-	4	-	-	-	-	-	10	-	-	-	-	4 Do, Sus. 10 WK.
Homonotus dorsalis, *Dixon*	-	-	-	3	4	-	-	7	-	-	-	-	-	-	-	3 Sus. 4 WK. 7 Sus.
„ rotundus, *A.S.W.*	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 EK.
Hoplopteryx lewesiensis, *Mant.*	-	-	-	-	4	-	-	7	-	9	10	-	-	-	-	4 F, Do. 7 Sus. 9 Sur. 10 WK.
„ simus, *A.S.W.*	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 EK, Sur. Sus.
„ superbus, *Dixon*	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	7 Sus.
Hypsodon lewesiensis, *see* Pachyrhizodus Gardneri).																
„ *minor* (*see* Ichthyodectes).																
Ichthyodectes elegans, *Newt.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Dorking.
„ minor, *Egerton*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Kent and Sussex.
„ tenuidens, *A.S.W.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	L.C. Kent.
„ sp. - - -	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Sur.
Leptotrachelus elongatus, *Ag.*	-	-	-	3	4	-	-	-	-	9	-	-	-	13	-	3 Sus. 4 Bd, He, Cam. WK. 9 WK. 13 Nor.
Microdon nuchalis (*see* Aipichthys)																
„ occipitalis, *Ag.* -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus (doubtful species).
Osmeroides *crassus*, (*see* Elopopsis.)																
lævis, *A.S.W.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Kent, Sus.
„ lewesiensis, *Mant.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	Ch. of Sussex. 13 Nor.
„ *granulatus* (*see* Halec eupterygius).																
Mantelli (*see* O. lewesiensis).																

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PISCES—Cont.																
Teleostomi—Cont.																
Pachyrhizodus basalis, *Dixon*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Steyning (Sussex).
„ Gardneri, *Mason*	-	-	-	3	4	-	-	-	-	-	10	-	-	-	-	3 F, Sus. 4 WK. 10 Sur.
„ Dibleyi, *A.S.W.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Burham.
„ subulidens, *Owen*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Kent, Sus.
„ *gracilis* (*see* Mosasaurus).																
Platax nuchalis (*see* Aipichthys).																
Plethodus expansus, *Dixon*	*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus.
„ oblongus, *Dixon*	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	3 Sus. 4 WK.
„ pentagon, *A.S.W.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Kent, Sur, Sus.
Plinthophorus robustus, *Günther.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Ch. of Sussex.
Pomognathus eupterygius (*see* Halec).																
Portheus Daviesi, *Newton*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. (Kent).
„ gaultinus, *Newton*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. (Kent).
„ Mantelli, *Newton*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus.
Prionolepis angustus, *Eg.*	-	-	-	-	4	-	-	-	-	-	10	-	-	-	-	4 Do. Sus. Cam. 10 Nor.
Protelops anglicus, *A.S.W.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Glynde (Sussex).
Protosphyræna ferox, *Leidy*	-	1	-	3	4	5	6	7	8	9	10	11	12	13	-	1 Cam. 3 F, Sus. 4 Ha, Bk, He. 5 Cam. 6 Ha, Cam. 7 Ha. 8 Es. 9 WK. 10 WK, Es. 11 Mar. 12 Ha, Sal. 13 Nor.
„ compressirostris, *A.S.W.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Chalk, Kent.
„ minor, *Ag.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	S.E. of England.
Sardinioides illustrans, *A.S.W.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	loc. unknown.
Saurodon intermedius, *Newton*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Do.
„ *lewesiensis* (*see* Cimolichthys).																
Saurocephalus (*see* Protosphyræna).																
Stenostoma pulchellum, *Dixon*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Steyning (Sussex).
Stratodus anglicus (*see* Protelops).																
Syllæmus anglicus, *Dixon*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus. LC. Kent, Sur.
Tetrapterus minor, (*see* Protosphyræna).																
Thrissopater magnus, *A.S.W.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. (Kent), Sus.
„ megalops, *A.S.W.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. (Lewes).
Tomognathus mordax, *Dixon*	-	-	-	3	4	-	-	-	-	-		-	-	13	-	3 Sus. 4 WK, He, Ha. 13 Nor.
„ *leiodus* (*see* T. mordax).																
Trachichthyoides ornatus, *A.S.W.*	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 WK.
Urenchelys anglicus, *A.S.W.*	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	7 Sus.

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CEPHALOPODA.																
Ammonidea.																
Ammonites.—																
[Acanthoceras] carolinus *d'Orb.*	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	7 Sus.
" cenomanensis, *d'Arch.*	-	-	2	3	4	-	-	-	-	-	-	-	-	-	-	2 Ch. 3 F. NW. 4 IW, Bd, He, Cam, Suf, Nor.
" Cunningtoni, *Sharpe*	-	-	2	3	4	-	6	-	-	-	-	-	-	-	-	2 Dev. 3 Wil. 4 Bk. 6 Do, Ha, SD, Dev.
" deverianus, *d'Orb.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 IW and (Grey Chalk) Sus.
" hippocastanum, *Sow.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dor, Ch, Dev.
" " var. compressa, *J-Br.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
" laticlavius, *Sharpe*	-	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 IW. 2 Dev. 3 IW. 4 Sp.
" Mantelli, *Sow.*	*	1	2	3	4	-	6?	-	-	-	-	-	-	-	-	Common in 1, 2, 3. 4 Sus. 6? Ha.
" navicularis, *Mant.*	*	1	2	3	4	-	6	-	-	-	-	-	-	-	-	Common in 1, 2. 3. 4 Sus. 6 Ha, Dor. Dev.
" Newboldi, *Kossmat.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dor, Ch.
" nodosoides, *Schlüter*	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	6 Do, Sus, Nor, He.
" pentagonus, *J-Br.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
" rotomagensis *Defr.*	-	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 E. 2 Dor, Ch. 3 F, Sur, Ha, Sus, NW. 4 common.
" rusticus, *Sow.*	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	6 Dev, Nor.
" sussexiensis, *Mant.*	-	-	-	3	4	-	6	-	-	-	-	-	-	-	-	3 Sus, SD. 4 Sus. 6 Ha.
[Desmoceras] *mayorianus* (*see* planulatus.)																
" octosulcatus, *Sharpe.*	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2 Ch. 3 IW.
" planulatus, *Sow.*	*	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 IW. MB. 2 Dor, Ch, Dev 3 Sus, IW. 4 Nor.
" pseudo-gardeni? *Schlüter*	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 Yo.
[Douvilléiceras] euomphalus, *Sharpe*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dor, Dev.
[Haploceras] Austeni, *Sharpe*	-	-	2	3	4	-	-	-	-	-	-	-	-	-	-	2 Dev. 3 Sus, Nor. 4 common.
" catinus, *Mant.*	-	-	-	-	4	-	6	-	-	-	-	-	-	13	-	4 Sus. 6 Do. 13 Nor.
" cinctus, *Mant.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus.
" icenicus, *Shpe.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
" leptophyllus, *Sharpe*	-	-	-	-	-	-	-	-	-	-	10	11	12	-	-	10 WK, Do. SD, Re, 11 Mar, Sal. 12 Sus.
" lewesiensis, *Mant.*	-	-	-	3	4	5	6	-	-	-	-	-	-	-	-	? 3 F. 4 Sus, Nor. 5 Bk. 6 Ha, Sus, Nor.
" undatus, *Sow.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Upper Chalk, Sussex
" vectensis, *Sharpe*	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 IW. 2 Dor.
[Hoplites] Bunburyanus, *Sharpe*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Ch.
" curvatus, *Mant.*	*	1	2	3	-	-	-	-	-	-	-	-	-	-	-	1 IW, MB, NW. 2 Dev, Ch. 3 Sus.
" falcatus, *Mant.*	*	1	2	3	-	-	-	-	-	-	-	-	-	-	-	1 IW, MB, NW. Ox. 2 Dev, Ch. 3 F, IW, Dor.
feraudianus ?, *d'Orb.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 IW (requires confirmation).

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CEPHALOPODA.—Cont.																
Ammonidea.—Cont.																
Ammonites—*Cont.*																
[Hoplites] ramsayanus, *Shpe*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Ch.
" renauxianus, *Shpe* (*non d'Orb*).	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 IW.
" Salteri, *Sharpe* -	*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Ch.
" Saxbyi, *Sharpe* -	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 IW. 3 IW.
[Lytoceras] Jukesi, *Sharpe*	-	-	-	-	-	-	-	-	-	-	-	-	12	13	-	12 Ha. 13 Sal, Nor.
" ? leptonema, *Sharpe*	-	-	?	3	-	-	-	-	-	-	-	-	-	-	-	? 2 Dev. 3 IW.
[Pachydiscus] Oldhami, *Shpe*																
" peramplus, *Mant.*	-	-	-	-	-	-	6	7	8	-	-	-	-	-	-	6 Common. 7 Do, Ha, Sus. 8 Common.
" *prosperianus* (*see* peramplus).																
" Portlocki, *Shpe*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
" Weisti, *Sharpe*	-	-	2	-	-	-	-	-	8	-	-	-	-	-	-	2 Ch. 8
[Phylloceras] Pergensi *de Gross*	?	-	-	3	-	-	-	-	-	-	-	-	-	13	-	3 IW. 13 Nor.
" *velledæ, Sharpe non Mich.* (*see* Pergensi).																
[Placenticeras] *complanatus* (*see* Largilliertianus).																
" largilliertianus *d'Orb.*	-	1	2	3	-	-	-	-	-	-	-	-	-	-	-	1 IW, MB. 2 Dev. Sus.
" obtectus, *Shpe.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev, Ch.
[Prionocyclus] *bravaisianus, Sharpe non d'Orb.* (*see* Neptuni).																
" Neptuni, *Gein.* -	-	-	-	-	-	-	6	7	8	-	-	-	-	-	-	6 Dev. 7 Ha. 8 NW, Be, Bk, Bd, He.
[Prionotropis] Woolgari, *Mant*	-	-	-	-	-	-	6	7	8	-	-	-	-	-	-	6 ? IW. 7 Sus. 8 NW
[Schoenbachia] Coupei, *Brongn.*	*	1	2	3	4	-	-	-	-	-	-	-	-	-	-	Common in 1, 2, 3. 4 Cam.
" goupilianus, *d'Orb.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus.
" Renevieri, *Sharpe*	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	3 I W. & Wilts.
" varians, *Sow.* -	*	1	2	3	4	-	-	-	-	-	-	-	-	-	-	Common in 1, 2, 3, 4 Cam.
Ammonites Wiltonensis found to be part of Scaphites Geinitzi.																
Anisoceras alternatus, *Mant.*	*	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 IW. 3 Sus.
" angustus, *Sow.* -	-	1	-	-	-	-	-	7	-	-	-	-	-	-	-	1 IW. 7 Sus.
" armatus, *Sow.* -	*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2 Ch. 3 Common.
" pseudelegans, *P. and C.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 IW.
" sp.	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 E, IW.
Baculites baculoides *Mant.*	*	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 E, IW, W. 2 Dor, Ch. 3 passim. 4, Sus, Bk.
" bohemicus, *Fritsch.*	-	-	-	-	-	-	6	-	8	-	-	-	-	-	-	6 Ha. 8 Common.
" Faujasi, *Sow.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	13	14	13 Nor. 14 Tr.
" sp. - - - -	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	5 Dor.
Crioceras ellipticum, *Mant.*	-	-	-	3	-	-	-	-	8	-	-	-	-	13	-	3 F, Sus. 8 Common. 13 Nor ?
Hamites simplex, *d'Orb.* -	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 E. 2 Dor. Dev.
" plicatilis, *Mant.* -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	Sus.
" sp. 1 - - -	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 Yo.
" sp. 2 - - -	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Be, Ox.
Heteroceras polyplocum ?, *Ræmer.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
CEPHALOPODA—Cont.																
Ammonidea—Cont.																
Heteroceras reussianum, *d'Orb.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Be, Bk, Bd, He.
„ sp.	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dor.
„ sp.	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Be, Bd, He.
Ptychoceras Smithi, *Woods*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Be, He.
Scaphites æqualis, *Sow.*	*	1	2	3	4	5	-	-	-	-	-	-	-	-	-	1 F, E, IW, MB. 2 Dor, Ch, Dev. 3 Common. 4 Cam.
„ „ var. obliquus, *Sow*	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2 Dor. 3 IW, Sus.
„ binodosus, ? *Ræm.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
„ Geinitzi, *d'Orb.*	-	-	-	-	-	-	-	7	8	-	-	-	-	-	-	7 Cam. 8 Common.
„ inflatus, *Defr.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
„ sp. (? Geinitzi)	-	-	-	-	-	-	6	-	-	9	-	-	-	-	-	6 Ha. 9 Bk.
Turrilites Bechei, *Sharpe*	*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ Bergeri, *Brongn.* var.	*	1	2	3	-	-	-	-	-	-	-	-	-	-	-	1 E, IW. MB. NW. 2 Dor, Ch. 3 IW, Be.
„ bifrons?, *d'Orb.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 IW.
„ costatus, *Lam.*	-	-	2	3	4	-	-	-	-	-	-	-	-	-	-	2 Dor, Ch. 3 passim. 4 Cam, Nor.
„ gravesianus, *d'Orb.*	-	1	2	3	-	-	-	-	-	-	-	-	-	-	-	1 IW. 2 Dev. 3 Sus, Bk.
„ Mantelli, *Sharpe*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus, IW, Bk, Bd, He.
„ Morrisi, *Sharpe*	-	1	2	3	-	-	-	-	-	-	-	-	-	-	-	1 E, IW, MB. NW. 2 Ch. 3 IW.
„ ? puzosianus, *d'Orb*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 IW.
„ Scheuchzerianus, *Bosc.*	-	-	2	3	4	-	-	-	-	-	-	-	-	-	-	2 Dev. 3 passim. 4 Bd, He, Cam.
„ tuberculatus, *Bosc.*	*	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 IW, Sus. MB. NW, 2 Dor, Ch. Dev. 3 Common. 4 Cam, Nor.
„ Wiesti, *Sharpe*	*	1	2	3	-	-	-	-	-	-	-	-	-	-	-	1 I W. MB. 2 Dor, Ch. 3 Sus, IW.
Aptychus gollevillensis, *Sharpe*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ icenicus, *Sharpe*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ leptophyllus, *Sharpe*	-	-	-	-	-	-	-	-	-	-	-	11	12	13	-	11 Mar, Sus. 13 Sal, Ha, Sus, Mar.
„ peramplus, *Sharpe*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
„ Portlocki, *Sharpe*	-	-	-	-	-	-	-	-	-	-	-	-	12	13	-	12 Sal, Ha. 13 Nor.
„ rugosus, *Sharpe*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor, IW, Sal.
„ sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 WK.
„ sp.	-	-	-	-	-	-	-	-		-	-	-	-	13	-	13 IW.
Belemnoidea.																
Actinocamax lanceolatus, *Sow.*	-	-	2	3	4	-	-	-	-	-	-	-	-	-	-	2 Dev. 3 F. 4 Bd, He, Cam (Tott. St.).
„ granulatus, *Blainv.*	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11 Common. 12 Passim.
„ *Merceyi* (see granulatus																
„ plenus, *Blainv.*	-	-	-	-	4	5	-	-	-	-	-	-	-	-	-	4 Ha, Bd, Nor, Suf. 5 Common.
„ quadratus, *Defr.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 SD. IW, Ha, Sal.
„ Toucasi, *Janet*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
„ verus, *Miller*	-	-	-	-	-	-	-	-	-	-	10	11	12	-	-	10 Sal, Ha. 11 Common. 12 Yo.
„ westfalicus, *Schlüt.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Wk.

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		Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
CEPHALOPODA—Cont.																
Belemnoidea—cont.																
Belemnites ultimus, *d'Orb.*	*	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 E, MB. 3 Nor, IW. 4 Nor.
Belemnitella lanceolata, *Schloth.*	-	-	-	-	-	-	-	-	-	-	10	11	12	13	14	10 WK. 11 Nor. 12 Sal, ND, Ha. Suf. 13 IW, SD, Nor. 14 Tr.
„ mucronata, *Schloth.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	14	13 passim. 14 Tr.
„ cf. strehlensis, *Fritsch.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Nor.
„ sp. (? new)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
Nautiloidea.																
Nautilus atlas, *Whit.*	-	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 ? MB. 3 Sus, Do. IW. 4Bd, WK.
„ *archiacianus, d'Orb.* (*see* expansus.)																
„ Bayfieldi, *F. & C.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	14	13 Nor. 14 Tr.
„ Deslongchampsianus, *d'Orb.*	*	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 common. 2 Dor, Ch, Dev. 3 common. 4 Cam, Suf.
„ cf. darupensis *Schlüt.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
„ elegans, *Sow.*	*	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 F, MB. 3 and 4 common.
„ expansus, *Sow.*	?	1	2	3	4	5	-	-	-	-	-	-	-	-	-	1 IW, MB, NW. 2 Dor, Ch. 3 Sus, SD, Do, Wilts. 5 E.
„ Fittoni, *Sharpe*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 IW, MB, NW. 2 Dor, Ch Dev.
„ fleuriausianus, *d'Orb.*	?	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2 Ch, Dev. 3 Sus.
„ largilliertianus, *d'Orb.*	*	1	2	3	-	-	-	-	-	-	-	-	-	-	-	1 F, IW, MB. 2 Dor, Ch, Dev. 3 Sus.
„ semiundatus? *Foord*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 MB.
„ sublævigatus, *d'Orb.*	*	1	2	3	-	-	6	-	8	-	-	-	-	-	-	1 E, IW, MB. 2 Dor. 3 common. 6 Ha. 8 common.
„ subradiatus ?, *d'Orb.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev. ?
„ triangularis, *Mont*	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2 Dev. 3 F (S.M.).
„ undatus, *Sow.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Upper Chalk.
„ undulatus, *Sow.*	*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Ch.
„ sp.	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 F. 3 F.
„ sp. (reflectus, *Seeley* MS).	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 Cam.
Rhynchoteuthis	-	-	-	-	-	-	-	-	-	-	-	-	12	13	-	12 Sal. 13 IW.
GASTEROPODA.																
Acmæa tenuicosta, *d'Orb.*	*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 F.
„ sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
Actæon (near to affinis *Sow.*)	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 IW.
„ elongatus. *Sow.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 F, IW, MB.
Avellana cassis, *d'Orb.*	-	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 IW, MB. 2 Dor, Ch, Dev. 3 Sus, He, Ox, Bk. 4 He, (Tott. St.).
„ Humboldti ?, *Müller*	-	-	-	-	-	-	-	-	8		-	-	-	13	-	8 Common ? 13 Nor.
„ Prevosti, *d'Arch.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Aporrhais (cf. cingulata *P & R.*)	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	(Tridactylus).
carinata ?, *Sow.*	*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	(Anchura). 3 Bk.

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GASTEROPODA—Cont.																
Aporrhais doratochila, *Gard.*	*	–	–	3	–	–	–	–	–	–	–	–	–	–	–	(Dimorphosoma) 3 F.
„ mailleana ?, *d'Orb.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ Mantelli, *Gard.* -	–	1	–	3	–	5	6	–	8	–	–	–	–	–	–	1 MB. 3 F, Sus. 5 Chilton. 6 IW. 8 Do, Ha, Be, Bd.
„ oligochila, *Gard.* -	*	–	–	3	–	–	–	–	–	–	–	–	–	–	–	(Tessarolax). 3 F E, IW.
„ opeatochila, *Gard.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	(Helicaulax). 3 F.
„ pachysoma, *Gard.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	(Tessarolax). 3 F.
spathochila, *Gard.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	(Dimorphosoma). 3 F.
„ stenoptera (? = Mantelli).	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 SD, Sal. ?
„ subtuberculata, *Gard.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 De, Bd.
„ sp. - - - -	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 Cam.
„ sp. - - - -	–	–	–	–	–	–	–	7	8	–	–	–	–	–	–	7 Do. 8 Do, Be.
Cassidaria incerta, *Sow.* -	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Chalk of Sussex (not Pterocera incerta, d'Orb.)
Cerithium cuckhamsliense, *Woods.*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be, Bd.
„ lallierianum ?, *d'Orb.*	–	–	2	3	–	–	–	–	–	–	–	–	–	–	–	2 Dev. 3 F.
„ ornatissimum, *d'Orb.*	*	–	–	3	4	–	–	–	–	–	–	–	–	–	–	3 Cam, Be, He.
„ Saundersi, *Woods.*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Do, Be, He.
„ trimonile? *d'Orb.*	*	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F.
„ *unicarinatum,* (*see* Nerinæa).																
„ sp. - - - -	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 IW, MB.
„ sp. - - - -	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
Cinulia (*see* Avellana).																
Cirrus striatus, *S. Woodw.*	–	–	–	–	–	–	–	–	–	–	10	–	–	–	–	10 Nor.
Columbellina (cf. maxima, *de Lor.*)	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB, IW. 2 WD, Dev.
„ sp. - -	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 MB.
Crepidula sp. - - -	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 De.
„ sp. - - -	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be.
Dentalium majus, *Gard.* -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F, Cam.
„ medium ? *Sow.* -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F.
„ planicostatum, *Heb.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	14	13 Sal, IW, Do, Nor. 14 Tr. ?
„ rotomagense, *d'Orb.*	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB. 2 Ch.
„ turoniense, *Woods.*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be, Bd, Ha, Ox, Do.
„ sp. (striated) -	–	1	2	–	4	–	–	–	–	–	–	–	–	–	–	1 E. 2 Ch, Dor. 4 Bd.
Dolium nodosum, *Sow.* -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	(? Pterocera). 13 Sus.
„ sp. - - - - -	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
Emarginula *affinis*, *Sow* (*see* E. Sanctæ-Catharinæ. -																
„ Gresslyi, *P C.*	*	1	2	3	–	–	–	–	–	–	–	–	–	–	–	1 De. MB. 2 Dor. 3 F IW.
„ Meyeri, *Gard.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ pelagica, *Passy*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Ch.
„ Sanctæ-Catharinæ, *Passy.*	–	1	2	3	–	–	–	–	8	–	–	–	–	–	–	1 W. 2 SD. 3 Sus. 8 Be, Bd.
„ unicostata, *Seeley*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
„ sp. - - - -	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be.
Funis crebricostatus, *Gard.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Upper Chalk.
Fusus bilineatus, P. and C. (*see* Murex).																
„ sp. - - - - -	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 De.
„ sp. - - - - -	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev, Ch.
„ sp. - - - - -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F.

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GASTEROPODA – Cont.																
Hipponyx Dixoni, *Desh.* -	–	1	–	–	–	–	–	–	–	9	10	–	–	–	–	1 Cam. 9 WK. 10 WK.
„ sp. - - -	–	–	–	–	–	–	–	–	–	–	10	11	12	13	–	10 Ek. Sal. 11 Mar. 12 Sal. 13 Sal.
Lampusia sp. - - -	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be.
Murex bilineatus? *P. & C.* -	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 E. I, MB. 2 Ch, Dor
Natica Genti, *Sow.* - -	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 IW. MB. 2Ch, Dev, ND.
„ vulgaris, *Reuss.* -	–	–	2	3	–	–	–	7	8	–	–	–	–	–	–	2 Dor. 3 Ox, Bk. 7 Ha. 8 Do, Ha, Be, Cam, Es.
„ sp. - - - -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F, Sus.
„ sp. (large)- - -	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
Nerinæa unicarinata, *S. Woodw.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
„ sp. - - - -	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Ch, Dev.
Phasianella. sp. - - -	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 De.
Phorus canaliculatus, *d'Orb.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Hamsey.
Pleurotomaria cassisiana, *d'Orb.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dor, Ch, Dev.
„ brongniartiana? *d'Orb.*	–	1	–	3	4	–	–	–	–	–	–	–	–	–	–	1 IW, MB, F, De. 3 IW, NW. 4 Cam.
„ *depressa*, (*see* Pl. perspectiva.)																
„ Guerangeri, *d'Orb.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	(seriato - granulata *Goldf.*) 3 Lewes.
„ mailleana, *d'Orb.*	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 IW. 2 Dev.
„ matheroniana, *d'Orb.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 De, MB.
„ moreausiana, *d'Orb.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 IW.
„ perspectiva, *Mant.*	–	1	2	3	4	–	6	7	8	9	10	11	12	13	–	1 IW. MB. 2 SD. 3 passim. 4, 6 Do. 7 and 8 common. 9 Do, Sus, WK. 10 Sus, EK, Sur 11 Mar. Yo. 13 Nor.
„ sp. 1 (flat) - -	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 De. MB.
„ sp. 2 (tall) - -	–	1	–	3	4	–	–	–	–	–	–	–	–	–	–	1 MB. NW. 3 Bd. 4 Bd, He.
„ sp. (cf. Thomsoni, *Tate*).	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Bd.
Pterodonta (tuberculate sp.)	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Devon.
„ sp. - - -	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB. 2 Ch.
Pterocera inflata, *d'Orb.* -	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 War. 2 WD.
Rostellaria Pricei, *Woodw.* -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F.
Scalaria dupiniana ?, *d'Orb.*	*	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F.
„ fasciata, *Eth.* (var. of decorata, *Roem.*,	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	3 Cam.
„ compacta, *Sow.* -	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Chalk, Sussex.
Solariella gemmata, *Sow.* -	–	–	–	3	–	–	–	7	8	9	–	–	–	–	–	3 Sus, Dev. 7 Do. 8 passim. 9 Do.
Solarium bicarinatum, *Tiess.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 MB, IW.
„ catenatum, *Sow.* -	–	–	2	3	–	–	–	–	–	–	–	–	–	–	–	(? Pleurotomaria) 2 Dor. 3 Sus.
„ dentatum ?, *d'Orb.*	*	1	–	–	4	–	–	–	–	–	–	–	–	–	–	1 MB, IW. 4 Cam.
„ granulatum, *Mant.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	1 E. 3 Sus.
„ martinianum, *d'Orb.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 De.
„ ornatum, *Sow.* -	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 E. MB, IW. 2 Dev, Dor.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
GASTEROPODA—Cont.																
Solarium thirrianum, *d'Arch.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ triplex, *P. & R.* -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1, ND. MB.
„ sp. - - - - -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Be.
Trochus berocscirensis, *Woods*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Be.
„ Basteroti? *Brongn.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ Buvignieri, *P. & C.* -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Ha.
„ girondinus? *d'Orb.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ goupilianus', *d'Orb.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 MB.
„ *linearis* (*see* Pleurotomaria).																
„ Schlüteri, *Woods* -	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 common.
„ sp 1 - - - -	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ sp. 2 - - - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ sp. 3 - - - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Ch.
Turbo *gemmatus, Sow.* (*see* Solariella																
„ Geinitzi, *Woods* - -	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 common.
„ Guerangeri, *d'Orb.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Dev.
„ retifer, Holz. - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ rotomagensis, *d'Orb.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Ch, WD.
„ (like Triboleti, *P.&C.*)	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 F.
„ tricostatus, *d'Orb.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ sp. 1 (or Gibbula) -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 De, E, IW, MB.
„ sp. 2 - - - - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dor, Ch.
Turritella Bauga, *d'Orb.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ cenomanensis, *d'Orb.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 E.
„ turbinata, *Sow.* -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sussex.
„ ? (thick smooth cast.)	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ sp. 1 - - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Ch.
„ sp. 2 - - -	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
Voluta Guerangeri, *d'Orb.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ semiplicata, *Gein.* -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 F.
„ ambigua, *Mant.* non *Brand* - - -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus.
LAMELLIBRANCHIATA.																
Anatina lanceolata, *Gein.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Anomia papyracea, *d'Orb.* -	-	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 NW. 3 IW, He. 4 He, Cam (Tott. St.).
„ subtruncata? *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ transversa, *Seeley* -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
„ sp. - - - - -	-	-	-	-	-	-	6	-	-	-	10	-	-	-	-	6 Dev. 10 WK.
„ sp. - - - - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Arca (Barbatia) Galliennei, *d'Orb.*	*	1	2	-	-	-	-	-	8	-	-	-	-	-	-	1 MB, De. 2 Ch, Dev. 8 Be, Bd, He.
„ „ cf. Geinitzi, *Reuss.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	14	8 Be. 14 Tr.
„ (Trigonoarca) passyana, *d'Orb.*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 De, MB. 2 Dev, Ch.
„ pholadiformis, *d'Orb.* -	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 IW, MB.
„ royana, *d'Orb.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 IW.
„ (Barbatia) vendinensis, *d'Orb.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev. (Meyer's bed 10).
Astarte cyprinoides, *d'Arch.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev, WD.
„ Konincki, *d'Arch.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Aucellina gryphæoides, *Sow.*	*	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 E, De, MB, IW, Cam. 3 passim. 4 Cam, Lin.
Avicula, cf. cærulescens, *Goldf.*																

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
LAMELLIBRANCHIATA—Cont.																
Avicula dubia, *Eth.*	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 Cam (Tott. St.).
„ filata, *Eth.*	–	–	–	3	4	–	–	–	–	–	–	–	–	–	–	3 IW. 4 Cam, Nor (Tott. St.).
„ lineata, *Ræm.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Yorks.
„ *gryphæoides* (see Aucellina																
„ nitida, *Woodw.* MS.	–	–	–	–	–	–	–	–	–	–	–	11	12	–	–	11 Nor. 12 Yo.
„ sp. (? nitida).	–	–	–	–	–	–	–	–	–	–	–	11	12	13	–	11 Mar. 12 Sal, Es. 13 Sal.
„ Roxelana, *d'Orb.*	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 Hun.
„ tenuicosta, *Ræm.*	–	–	–	–	–	–	–	–	–	–	–	11	12	–	–	11 Yo. 12 Sal, Suf.
„ subnodosa, *Hag.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
„ sp. nov.	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 Bd, He, Nor.
Caprotina sp.	–	–	–	–	–	–	–	–	8	–	10	–	12	–	–	8? IW. 10 Sus. 12 Ha.
Cardita cottaldina, *d'Orb.*	*	1	2	3	–	–	–	–	–	–	–	–	–	–	–	1 IW., MB. 2 WD, Ch. 3 IW.
„ cancellata, *Woods*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be, Ox, Bk, Bd, Cam.
„ dubia, *d'Orb.*	*	–	2	3	–	–	–	–	–	–	–	–	–	–	–	2 Ch. 3 Tring.
„ tenuicosta ? *Sow.*	*	1	2	3	–	–	–	–	–	–	–	–	–	–	–	1 IW. 2 Dor. 3 F, Sur, Be, Bk.
Cardium alternans, *Reuss*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ alutaceum, *Goldf.*	*	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ *hillanum*, *Sow.* (*see* Protocardium)	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 IW. 2 Dev.
„ mailleanum, *d'Orb.*	–	1?	2	–	–	–	–	–	8	–	–	–	–	–	–	1 De. 2 Dev, Dor. 8 Be.
„ cenomanense ?, *d'Orb.*	–	1	–	–	–	–	–	–	8	–	–	–	–	–	–	1 MB. 8 Be.
„ turoniense, *Woods*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be.
Chama cornucopiæ, *d'Orb.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev, Ch, Dor.
„ *inæquirostrata*, (*see* Diceras).																
Corbis Morisoni, *Woods*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be.
„ rotundata, *d'Orb.*	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB. 2 Dev, Ch.
„ sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	—
Corimya (*see* Thracia).																
Crassatella ligeriensis, *d'Orb.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ vindennensis, *d'Orb.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ sp. (casts)	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 IW.
Cucullæa (Grammatodon) carinata, *Sow.*	*	1	–	3	–	–	–	–	–	–	–	–	–	–	–	1 De, E. 3 F, IW, E, Ox, Bk.
„ mailleana, *d'Orb.*	*	1	2	3	–	–	–	–	–	–	–	–	–	–	–	1 De, IW, MB. 2 Dev, Ch, Dor. 3 E, NW. Ch.
„ Guerangeri, *d'Orb.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ nana ?, *Leym.*	*	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F.
„ obesa, P. & R.	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 IW, MB, NW.
„ sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
Cuspidaria caudata, *Nilss.*	–	–	2	–	–	–	–	–	8	–	–	–	–	13	–	2 Dor. 8 Be. ?13 Nor.
Cypricardia (*see* Trapezium)																
Cyprina æquisulcata, *Woods*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be.
„ quadrata, *d'Orb.*	*	1	2	–	–	–	–	–	8	–	–	–	–	–	–	1 IW, De. MB. 2 Ch, Dor. 8 NW. Be, Bd.
„ ligeriensis, *d'Orb.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ sp.	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 IW, De.
Cytherea sp.	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 De. 2 Dor.
Diceras inæquirostratum, *S. Woodw.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	14	13 Nor. 14 Tr.
Exogyra conica, *Sow.*		1	2	3	–	–	–	–	–	–	–	–	–	–	–	1 E, IW, MB. 2 Dev, Dor. 3 F, IW.
„ conica var. undata, *Sow.*	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 IW. 2 Dev

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	1 Chloritic Marl (Stauronema.)	2 Devon Cenomanian, &c.	3 Chalk Zone of Am. varians.	4 Zone of Hol. subglobosus.	5 Zone of Act. plenus.	6 Zone of Rhynch. Cuvieri.	7 Zone of Terebratulina.	8 Zone of Hol. planus.	9 Z. of Mic. cortestudinarium.	10 Zone of Mic. coranguinum.	11 Zone of Marsupites.	12 Zone of Act. quadratus.	13 Zone of Bel. Mucronata.	14 Zone of Ostrea lunata.	
LAMELLIBRANCHIATA—Cont.																
Exogyra haliotoidea, *Sow.* -	*	1	2	3	4	–	6	7	–	–	10	11	–	–	–	1 IW, E, MB, Cam. 2 WD, Dev. 3 passim. 4 passim. 6 He. 7 He. 10 Ha, EK. 11 Ha.
Gastrochæna sp. - - -	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
Gervillia sp. - - - -	–	1	–	–	–	–	–	–	8	–	–	–	–	–	–	1 MB.
Goniomya sp. - - -	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
Hinnites (*see* Pecten).																
Inoceramus Brongniarti, *Sow.*	–	–	–	–	–	5	6	7	8	9	10	11	12	13	–	5 Dor. 6 Ha, SD. 7 Do, Sus, Dev. 8 Do, Sus, Be, Es. 9 EK, WK, SD, Cam. 10 WK, Nor. 12 Sal.
„ *convexus, Eth.* (*see* striatus).																
„ cordiformis, *Sow.*	–	–	–	–	–	–	–	–	–	–	10	–	–	–	–	10 WK.
„ Cuvieri, *Sow.* -	–	–	–	–	4	–	6	7	8	9	10	11	12	13	–	? 4 Bk. 6 common, 7 passim. 8, 9 and 10 common. 11 Mar, Sus. SD. 12 Sus. SD. 13 SD.
„ Cripsi, *Mant.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Hamsey and Kent.
„ *cuneiformis* (*see* pictus)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
„ digitatus, *Sow.*	–	–	–	–	–	–	–	–	–	–	10	11	12	13	–	10 Sus, Sal, Yo. 11 WK. Yo. 12 Sal. 13 Nor.
„ giganteus Wdw.	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
„ inæquivalvis, *Schlüt.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	—
„ involutus, *Sow.*	–	–	–	–	–	–	–	–	–	9	10	11	12	–	–	9 and 10 common. 11 Ha. 12 Sus.
„ *labiatus, Schloth* (*see* mytiloides).																
„ Lamarcki, *Park.*	–	–	–	–	–	–	6	7	–	9	10	11	–	–	–	6 Ha, IW. 7 Do, Sus, He. 9 Sus, WK. 10 Sal, Nor. 11 Nor.
„ latus, *d'Orb.* non *Mant.*	*	1	2	3	4	–	6	–	–	–	–	–	–	–	–	1 De, IW, MB. 2 Dev, Ch, Dor. 3 passim. 4 Bd, He, Cam.
„ latus, *Mant* non *d'Orb.*	–	–	–	–	–	–	–	–	–	–	10	–	12	13	–	10 Sal. 12 Sal. 13 Nor
„ lingua, *Goldf.* -	–	–	–	–	–	–	–	–	..	–	–	11	12	–	–	11 Mar, Ha, Nor, Yo. 12 Sus, Yo.
„ mytiloides, *Mant.*	–	–	–	–	4	5	6	7	8	9	10	–	–	–	–	4 Cam, Norf. 5 passim. 6 passim. 7 Do, Ha, Sus. 8 SD. Dev. 9 Do, Sus. 10 Do (rare).
„ pictus, *Sow.* -	–	–	–	3	–	–	–	7	–	–	–	–	–	–	–	3 Wilts, SD. 7? Ha.
„ striatus, *Sow.* -	–	1	2	3	4	5	–	–	8	–	–	–	–	–	–	1 De, MB. 2 Dev, Ch, SD. 3 passim. 4 WK, Bk, Cam. 5 SD. 8 Sur, NW. Be, Bd.
„ striatus, var. convexus, *Eth.*	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 Cam.
„ tenuis, *Mant.* -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Hamsey, E.
„ undulatus, *Mant.*	–	–	–	–	–	–	6	–	8	9	10	–	–	–	–	6 Ha. 8 Sus. 9 WK. 10 Sur.

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	Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
LAMELLIBRANCHIATA—Cont.																
Inoceramus sp. - - -	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
„ sp. - - -	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	—
Janira, (*see* Pecten (Neithea).)																
Isoarca obesa, *d'Orb.* -	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 IW. 2 Ch, WD, MB.
Leda pulchra, *Sow.* (*see* Cuspidaria caudata.).																
„ *siliqua*, *Goldf* (*see* Nuculana).																
Lima *æqualis*, *Héb.* (*see* Spondylus).																
„ aspera, *Mant.* - -	–	1	–	3	4	–	–	–	–	–	–	–	–	–	–	1 E. MB. 3 passim. 4 Ox, Bk, He, Cam.
„ *astieriana*, *d'Orb.* (*see* L. elongata).																
„ cenomanensis, *d'Orb.*	*	–	–	3	4	–	–	–	–	–	–	–	–	–	–	3 Hun. 4 Hun, Der,
„ consobrina, *d'Orb.* -	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 IW.
„ decussata, *Goldf.* -	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
„ *dutempleana*, *d'Orb.* (*see* semisulcata).																
„ echinata, *Eth.* - -	–	–	–	3	4	–	–	–	–	–	–	–	–	–	–	3 WK. Cam, Hun, Lin, Sp. 4 Be, He, Cam.
„ elongata, *Sow.* - -	–	1	2	3	4	–	–	–	–	–	–	–	–	–	–	1 E, IW. 2 Dev. 3 passim. 4 WK, Hun.
„ Galliennei, *d'Orb.* -	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	—
„ globosa *Sow.* - -	*	1	2	3	4	–	–	–	–	–	–	–	–	–	–	Common from 1 to 4.
„ granosa, *Sow.* (in Dixon).	-	–	–	–	–	–	–	–	8	–	–	11	12	13	–	8 Ha. 11 SD. 12 Sal. 13 Sal, Nor.
„ granosa, *Goldf.* -	–	–	–	–	–	–	–	–	–	9	10	11	–	–	–	9 Sus. 10 EK, Sus. 11 Mar, Sus.
„ granulata, *Nilss.* -	–	–	–	–	–	–	–	–	–	9	–	–	–	13	14	9 WK. 13 Nor. 14 Tr.
„ Hoperi, *Sow.* - -	–	–	–	–	–	–	–	7	8	9	10	11	12	13	14	7 SD. Common from 8 to 13. 14 Tr.
„ intermedia ? *d'Orb.* -	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Ch.
„ læviuscula, *Sow.* (in Dixon).	–	–	–	–	–	–	–	–	–	9	10	11	12	–	–	9 WK. 10 Sal. 11 Sus, Sal. 12 Ha, Sal.
„ *Mantelli*, *d'Orb.* (*see* L. Hoperi).																
„ ornata, *d'Orb.* - -	*	1	2	3	–	–	–	–	–	–	–	–	–	–	–	1 IW, MB. 2 Dev, Ch. 3 IW.
„ ornata *Eth.* non *d'Orb.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
„ ovata, *Nilss.* - -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Hun.
„ pectinata, *d'Orb.* -	–	–	–	–	–	–	–	–	8	9	10	11	12	13	–	8 Ha. 9 IW. 10 IW, Ha. 11 Ha. Sal. 12 Sal, Ha. Sus. Suf, I W. 13 IW.
„ rapa, *d'Orb.* - -	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ Reichenbachi, *Gein.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ rotomagensis, *d'Orb.*	*	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ semiornata, *d'Orb.* -	*	1	2	3	–	–	–	–	–	–	–	–	–	–	–	1 E, MB. 2 Dev, SD. 3 SD.
„ semisulcata, *Sow.* -	*	1	2	–	–	–	–	7	8	–	–	–	–	13	14	1 MB, NW, 2 Dev, Ch, Dor. 7 SD. 8 IW. 13 Sal. 14 Tr.
„ semisulcate var. dutempleana, *d'Orb.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13 SD, Sal.
„ simplex, *d'Orb.* - -	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB. 2 Dev.
„ spinosa, *Sow.* (in Dix.)																(a doubtful species).
„ striata ? *Goldf.* -	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	—
„ subabrupta, *d'Orb.*	–	–	–	–	–	–	–	7	8	–	–	–	–	–	–	7 Ha. 8 Ha.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	1 Chloritic Marl (Stauronema)	2 Devon Cenomanian, &c.	3 Chalk Zone of Am. varians.	4 Zone of Hol. subglobosus.	5 Zone of Act. plenus.	6 Zone of Rhynch. Cuvieri.	7 Zone of Terebratulina.	8 Zone of Hol. planus.	9 Z. of Mic. cortestudinarium.	10 Zone of Mic. coranguinum.	11 Zone of Marsupites.	12 Zone of Act. quadratus.	13 Zone of Bel. Mucronata.	14 Zone of Ostrea lunata.	
LAMELLIBRANCHIATA—Cont.																
Lima tecta, *d'Orb*.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
,, sp.	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	6 Sus, Dev.
Limopsis sp.	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be.
Lithodomus rugosus, *d'Orb*.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev, Ch.
Lucina turoniensis ? *d'Orb*.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
Lutraria (*see* Thracia).																
Martesia rotunda, *Sow*.	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be.
Modiola capitata ? *Zittel*.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
,, *Cottæ* (see Septifer)																
,, divaricata, *d'Orb*.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
,, Guerangeri, *d'Orb*.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
,, ligeriensis, *d'Orb*.	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 E. 2 Dev.
,, *quadrata, Sow*. (*see* Septifer lineatus).																
,, striato-costata, *d'Orb*.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
,, (? arcacea, *Gein*.)	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
,, (? irregularis, *Gein*.)	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
Myoconcha cretacea, *d'Orb*.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Ch, WD.
Neæra (see Cuspidaria).																
Neithea (*see* Pecten (*Neithea*).)																
Nucula impressa ? *Sow*.	*	1	–	3	–	–	–	–	–	–	–	–	–	–	–	1 MB. 3 Do. (Gardner).
,, obtusa, *Sow*.	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Do. (Gardner).
,, *obesa* (*see* Isoarca).																
,, pectinata, var. cretæ, *Gard*.	–	–	–	3	–	–	–	–	–	–	–	–	–	–	14	3 F. 14 Tr.
,, cf. renauxiana, *d'Orb*.	–	–	–	3	–	–	–	–	8	–	–	–	–	–	–	3 Tring. 8 Bk, Be, Be, He.
Nuculana siliqua, *Goldf*.	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Be.
,, lineata ? *Sow*.	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	3 Do. (Gardner).
Opis bicornis ? *Gein*.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev, Ch, Dor.
Ostrea acutirostris, *Nilss*.	–	–	–	–	4	–	–	–	–	9	10	11	12	–	–	4 Sus, Cam, Lin. 9 WK. 10 EK, WK, Mid, Nor. Yo. 11 common. 12 Suf. Nor.
,, alæformis, *Woodw*.	–	–	–	–	–	–	–	–	–	–	10	11	12	13	–	10 EK. 11 Mar, Sus. 12 Sus. 13 Nor.
,, *canaliculata Sow*. (*see* O. lunata).	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Ostrea of Min, Con, pl. 135, not Chama of pl. 26.
,, canaliculata, *Sow*. (O. lateralis, *Nilss*.)	*	1	2	3	4	–	–	7	8	9	1	11	12	13	14	(Chama) Common in 1 to 4 and in 7 to 11. 12 Sus, Ha, Sal. 13 SD, 14 Tr.
,, *carinata, Sow*. (*see* frons).																
,, concentrica, *S. Wdw*.	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
,, cunabula, *Seeley*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
,, curvirostris, *Nilss*.	*	–	–	–	4	–	–	–	–	–	10	11	12	–	–	4 Cam, Lin. 10 Do 11 Mar. 12 common.
,, diluviana, *Linn*.	–	1	2	3	–	–	–	–	–	–	–	–	–	–	–	1 IW. 2 Dev. 3 Hun.
,, *flabelliformis, Nilss*. (*see* sulcata).																
,, frons, *Park*.	*	1		3	4	–	–	–	–	–	–	–	–	–	–	1 E, IW, MB, Cam. 2 Dev, Dor. 3 passim. 4 Bd, Cam.

SPECIES.	* Found in Selbornian.	Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
		Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
LAMELLIBRANCHIATA—Cont.																
Ostrea Goldfussi, *Holz.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
,, hippopodium, *Nilss.*	-	-	2	-	4	-	6	7	8	9	10	11	12	13	14	2 Dev. 4 WK, 6 Do, IW. 7 Do, Sus, IW. 8 Do, Ha. Cam. 9 to 14 common.
,, *inæquicostata, S. Wdw.* (*see* sulcata).																
,, lagena, *Seeley* - -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
,, larva, *Lam.* - -	-	-	-	-	-	-	-	-	-	-	-	11	12	13	-	11 Sal. 12 Sal. 13 Nor.
,, *lateralis* (*see* canaliculata).																
,, Lesueuri, *d'Orb.* -	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	3 He. 4 Hun. (?=*O. hippopodium*).
,, lunata, *Nilss.* - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Trim.
,, normaniana, *d'Orb.* -	-	1	2	3	4	5	6	7	8	9	10	11	12	13	-	Common throughout except in 5, 6, & 7.
,, *pectinata, Lam.* (*see* diluviana).																
,, semiplana, *Mant.* -	-	-	-	-	-	-	6	7	8	9	10	11	12	13	14	6 Sur, Sus. 7 Do, Sus, IW. 8 SD, Be, Cam. 9 to 12 common. 13 Sal, SD, Nor. 14 Tr.
,, sulcata, *Blum.* - -	-	-	-	-	-	-	-	-	-	-	-	11	12	13	-	11 WK. 12 Sal. 13 Sal, Nor.
,, triangularis, *S. Wdw.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
,, ungulata, *Schloth.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
,, vesiculosa, *Sow.* -	*	1	2	3	-	-	-	-	-	-	-	-	-	-	-	1 IW. MB, 2 Dev. 3 IW.
,, vesicularis, *Lam.* -	*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Common throughout.
,, ,, var. globosa, *Sow.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	14	13 Nor. 14 Tr.
,, virgata, *Sow.* (in Dixon).	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
,, wegmanniana? *d'Orb.*	-	-	-	-	-	-	-	-	-	-	10	11	12	13	14	10 Ha, Sal, IW. 11 & 12 common. 13 SD. 14 Tr.
Panopæa sp. (? Pleuromya)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 F, IW.
Pecten acuminatus? *Gein.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
,, arlesiensis, *Woods*	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	3 F. 4 He.
,, cf. asellus, *Sow.*	-	-	-	-	-	-	-	-	8	-	-	-	12	-	-	8 Ha, 12 Sal.
,, asper, *Lam.* - -	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 IW, MB, De, Be. 2 Dev, Ch, WD.
,, Beaveri, *Sow.* - -	*	1	-	3	4	-	-	7	-	-	-	-	-	?	-	1 IW, MB. 3 and 4 common. 7 Sus, Cam. 13 Nor.
,, britannicus, *Woods* -	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Sur, Sal.
,, campaniensis, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	11	12	13	14	11 Sal. 12 Sal. 13 Sal, Nor. 14 Tr.
,, *concentricus, S. Wdw.* (see mantellianus).																
,, cretosus, *Defr.*	-	-	-	-	-	-	6	7	8	9	10	11	12	13	14	6 Do. Ha. 7 Do. Nor. 8 Do. Sus. 9 Do. Sus. Sur. Common from 10 to 14.
,, *cretosus, Goldf.* (*see* elongatus).																
,, curvatus, *Gein.* -	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 E.
,, dubrisiensis, *Woods*	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	3 Cam. 4 He, Cam, Suf.
,, *Dujardini, Ræm.* (*see* pexatus).																
,, elongatus, *Lam.* -	*	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 IW. MB. 3 passim. 4 Bk, He, Cam.
,, fissicosta, *Eth.* - -	-	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 IW. 2 Dor, 3 F, Cam, Lin. 4 Bd, He, Cam. WK. Nor.

SPECIES.		Lower Chalk.					Middle Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
LAMELLIBRANCHIATA—Cont.																
Pecten *Galliennei, d'Orb.* - (*see* robinaldinus).																
„ hispidus, *Goldf.* -	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 Mel, MB. 2 Dev.
„ jugosus, *Sow.* in Dix.	–	–	–	–	–	–	–	–	–	–	–	11	–	13	–	11 Ha. ? 13 Nor.
„ *laminosus, Mant.* (*see* orbicularis).																
„ mantellianus, *d'Orb.*	–	–	–	–	–	–	–	–	–	–	10	–	–	13	–	10 Sur. 13 ND, Sa Nor.
„ Nilssoni, *Goldf.* -	–	–	–	–	–	–	–	–	8	–	–	–	12	13	14	8 NW. 12 Ha. Sus. 13 Nor. 14 Tr.
„ *nitidus, Mant.* (*see* cretosus).																
„ orbicularis, *Sow.* -	*	1	2	3	4	5	–	–	–	–	–	–	–	–	–	Common in 1, 3 and 4.
„ *Passyi, d'Arch.* - (*see* robinaldinus).																
„ pexatus, *Woods* -	–	–	–	–	–	–	–	7	8	–	–	11	12	13	–	8 He, Cam. 11 Mar. 12 Ha, Sal.
„ puzosianus, *d'Orb.* -	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB, ND. 2 Dev.
„ pulchellus, *Nilss.* -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	14	12 Sal. 14 Tr.
„ robinaldinus, *d'Orb.* -	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	Common in 1 and 2
„ var rotomagensis, *d'Orb.* - - -	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB, 2 Dev.
„ sarumensis, *Woods* -	–	–	–	–	–	–	–	–	–	–	–	–	12	13	–	12 Sal. 13 Sal.
„ serratus, *Nilss.* - -	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
„ subacutus, *Lam.* -	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB. 2 Dev.
„ *subinterstriatus* (*see* robinaldinus)																
„ undulatus, *Nilss* -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	14 Tr.
„ (Hinnites) sp. nov. -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Ox.
„ „ sp. - -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 Sal.
„ (Neithea) æquicostatus, *d'Orb.*	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB. 2 Dev.
„ „ cometa, *d'Orb.*	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 IW, MB. 2 Dev.
„ „ decemcostatus, *Münst.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ „ Dutemplei, - *d'Orb.*	–	–	–	–	–	–	–	–	–	–	10	–	12	13	–	10 EK, Ha, IW. 11 Mar. 12 Sus, IW, Sal. 13 IW.
„ „ phaseola, *Lam.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ „ quadricostatus, *Sow.*	*	1	2	3	4	–	–	–	–	–	–	11	–	–	–	1 MB. 2 Dor, Dev. 3 F. 11 Sus.
„ „ quinquecostatus, *Sow.*	*	1	2	3	4	?	?	7	8	9	10	11	12	13	14	Common throughout except in 5 and 6.
„ „ sexcostatus, - *S. Woodw.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	UC, Nor. (probably = N. Dutemplei).
Pectunculus euglyphus, - *Woods.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
Perna sp. - - - -	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Ch.
Pinna decussata, *Goldf.* -	?	–	–	3	4	–	–	7	8	–	–	11	12	–	–	3 Sus. 4 WK. 7 Wilts. 8 Cam. 11 WK. 12 Sal.
„ sulcata, *Woodw.* -	–	–	–	–	–	–	–	–	–	–	–	–	–	13	14	13 Nor. 14 Tr.
„ tegulata, *Eth.* - -	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 Cam.
„ (like tetragona, *Sow*).	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
Plicatula Barroisi, *Peron* -	–	–	–	–	–	–	6	7	8	9	–	–	–	–	–	6 IW. 7 Do, Dev. 8 SD, Dev, Bd. 9 Dev.
„ gurgitis, P. & R. -	*	1	2	3	4	–	–	–	–	–	–	–	–	–	–	Common from 1 to 4.
„ inflata, *Sow.* - -	*	1	2	3	4	–	–	–	–	–	–	–	–	–	–	Common from 1 to 4.
„ minuta, *Seeley* -	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
„ *pectinoides*, (*see* - gurgitis) - -																
„ sigillina, *S.P. Wdw.*	*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Common throughout.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
LAMELLIBRANCHIATA—Cont.																
Pholas sp. - - - - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 WD.
Placunopsis undulata ?,*Holz.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
Pholadomya æquivalvis, *Goldf.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ decussata, *Phil.*	*	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 MB. 3 passim. 4 Be, He, Cam.
„ mailleana, *d'Orb.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Ch. Dev.
„ sp. (? decussata) -	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	? 13 Nor.
Protocardium hillanum,*Sow.*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 IW. 2 Dev
Radiolites Mortoni, *Mant.* -	-	1	-	3	-	-	6	7	-	-	-	11	-	-	-	1 Cam. 3 F, Sus, IW. 6 Do. 7 He. 11 WK.
„ cf. angeoides *Lam.*	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	7 Dev.
Septifer lineatus, *Sow.* -	*	1	2	3	-	-	-	-	8	9	10	11	12	13	-	1 MB. 2 Dor, Ch, Dev. 3 Sus. 8 common. 9 WK, Lin. 10 Ha. 11 WK, Ha. 12 Ha, Sal. 13 Nor.
Solen æqualis, *d'Orb.* - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Spondylus *æqualis*, *Heb.* (*see* spinosus)																
„ *æquicostatus*, *Eth.* (see latus)																
„ complanatus ? *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ dutempleanus, *d'Orb.* (probably the fimbriatus of *Goldf.*).	-	-	2	3	4	-	6	7	8	9	10	11	12	13	14	2 Dev. 3 F. 4 Yo, 6 Sus. 7 Do, Ha, Sur. 8 Sus, IW. 9 Do, WK. 10, 11 and 12 common. 13 Sal, SD, Nor. 14 Tr.
„ latus, *Sow.* - -	-	-	-	3	4	-	6	7	8	9	10	11	12	13	14	3 F, Sus, Hun. 4 Cam. Common in 6 to 14.
„ *lineatus* (see latus).																
„ *obliquus*, *Sow.* (see latus)																
„ Omalii, *d'Arch.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ serratus, *Woods* -	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 Do, Sal.
„ spinosus, *Sow.* -	-	-	-	-	-	-	6	7	8	9	10	11	12	13	14	6 Do. Common from 7 to 13. 14 Tr.
„ striatus, *Sow.* -	*	1	2	3	4	-	-	-	-	-	-	11	12	-	-	1 MB, De. 2 Dev. 3 passim. 4 He, Cam. 11 Sus. 12 Sus.
„ truncatus?,*d'Orb.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Yo.
Tellina royana, *d'Orb.* - -	-	-	-	-	-	-	-	-	-	-	-	-	12	13	-	12 Sal. 13 Sal.
Teredo amphisbæna, *Sow.* -	-	1	-	3	4	5	6	7	8	9	-	11	-	-	-	1 E, MB, Cam. 3 to 6 common. 7 Ha, 8 Bd. 9 SD. 11 WK, Sal.
„ *rotundus*, *Sby.* in Dix. (*see* Martesia).																
Thetis Sowerbyi. *Rœmer* -	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 MB.
Thracia carinifera, *d'Orb.* -	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 De, MB. 2 Dor, Ch.
Trapezium rectangularis, *Woods.* -	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Be.
„ trapezoidalis, *Rœmer.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Be, Bk, Bd, Es Cam.
Trigonia affinis, *Sow.* - -	*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev, Ch.
„ costigera, *Lyc.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ crenulata, *Lam.* -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ crenulifera, *Lyc.* -	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1? MB. 2 Dev, Ch.
„ debilis, *Lyc.* - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ dunscombensis, *Lyc.*	-	-	2	-	-	-			-	-	-	-	-	-	-	2 Dev.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS
	Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
LAMELLIBRANCHIATA—Cont.																
Trigonia *excentrica* (*see* affinis).																
„ Meyeri, *Lyc.* - -	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev, Ch.
„ pennata, *Sow.* -	*	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ sulcataria, *Lam.* -	*	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ vicaryana, *Lyc.* -	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB. 2 Dev, Ch.
Unicardium ringmeriense, *Mant.*	*	1	2	3	–	–	–	–	–	–	–	–	–	–	–	1 IW, MB. 2 Dev, Ch, Dor. 3 Sus.
Venus Goldfussi, *Gein.* -	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ rotomagensis, *d'Orb.*	?	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 IW, MB. 2 Dor, Ch
BRACHIOPODA.																
Argiope (*see* Cistella).																
Cistella Bronni, *de Hag* -	–	–	–	–	–	–	–	–	–	–	–	11	–	–	14	11 WK. 14 Tr.
Crania cenomanensis, *d'Orb.*	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 IW. 2 Dev, Dor.
„ egnabergensis, *Retz* -	–	–	2	–	–	–	–	7	8	9	10	11	12	13	14	2 Dev. 7 Do. 8 Do. Sus, SD. 9 to 14 common.
„ „ var. costata, *Sow.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Sal, SD.
„ parisiensis, *Defr.* -	–	–	–	–	–	–	–	–	8	9	10	11	12	–	14	8 SD. 9 to 11 common. 12 Ha, Sus, Nor. 14 Tr.
„ spinulosa, *Nilss.* -	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
Kingena lima, *Defr.* - -	*	1	2	3	4	–	–	7	8	–	10	11	12	13	–	1 IW, BM.Ca r. 2 Dev, Dor. 3 passim. 4 F, Cam, He, Nor. 7 Dev. 8 Bd. Lin. 10 to 13 common.
„ „ var. Hebertiana, *d'Orb.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Chalk, Norwich.
„ sexradiata, *Deslong*	–	–	–	–	–	–	–	–	–	–	10	11	12	13	–	10 Ha, Sus, IW. 11 Ha, Yo. 12 Ha, Sus. 13 IW.
Lingula subovalis ?, *Dav.* -	*	1	–	–	–	–	–	–	–	–	–	–	–	–	14	1 MB. 14 Tr.
Lyra Meadi, Cumb. (*see* Terebrirostra).																
Magas Geinitzi, *Schloenb.* -	–	–	2	3	4	–	–	–	–	–	–	–	–	–	–	2 Dev. 3 IW. 4 Hun.
„ pumilus, *Sow.* - -	–	–	–	–	4	–	–	–	–	–	–	11	12	13	14	4 Lin? 9 Lin. 10 Be. 11 WK. 12 Sal. Nor. 13 common. 14 Tr.
Megathyris *Bronni* (see Cistella)																
„ megatrema, *Sow.*	*	1	–	–	–	–	–	–	–	–	10	–	–	–	–	1 Cam. 10M.
Rhynchonella Cuvieri, *d'Orb.*	–	–	–	3	4	5	6	7	8	9	–	–	–	–	–	3 Norf. 4 Bd? 5 passim. 6 passim. 7 passim. 8 and 9 common.
„ „ round var.	–	–	–	–	–	–	6	7	–	–	–	–	–	–	–	6 Nor. 7 Do, He, Lin.
„ dimidiata, *Sow.*	*	1	2	–	–	–	6	–	–	–	–	–	–	–	–	1 IW, MB. 2 Dev, Chard, WD, SD. 6 Dev.
„ „ var. convexa, *Sow.*	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB. 2 Dev, Chard WD.
„ grasiana, *d'Orb.*	*	1	2	3	4	–	–	–	–	–	–	–	–	–	–	1 E, IW, MB, De. 2 Dev, Chard, WD. 3 common. 4 F, Cam, Nor.
„ limbata, *Schloth.*	–	–	–	–	–	–	–	7	–	9	10	11	12	13	14	7 Do, Sus. 9 Do, Sur, WK, Sus. 10 to 14 common.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
BRACHIOPODA—Cont.																
Rhynchonella lineolata, var. Carteri, *Dav.*	-	1	2	3	4	-	-	-	-	-	-	-	-	13	-	1 Cam, IW. 3 E, Do. Sp, Hun. 4 Nor. 13 SD.
„ mantelliana, *Sow.*	*	1	2	3	4	-	6	-	-	-	-	-	-	-	-	1 Cam, IW, MB. 2 Dev. Dor. 3 and 4 passim. 6 IW, Cam.
„ Martini, *Mant.*	*	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 Cam, E, IW. 2 WD. 3 passim. 4 Do. Cam, Be, He, Nor.
„ plicatilis, *Sow.* -	-	-	-	-	-	5	6	7	8	9	10	11	12	13	14	5 passim. 6 Ha, Sur, Dev. 8 to 13 common. 14 Tr.
„ „ var. octoplicata, *Sow.*	-	-	-	-	-	-	-	-	8	9	10	11	12	13	-	Common in 8 to 13.
„ „ var. Woodwardi, *Sow.*	-	-	-	-	-	-	-	7	-	-	10	11	-	13	-	7 Do. 10 Sal. 11 Sal. 13 Nor.
„ reedensis, *Eth.*	-	-	-	-	-	-	6	7	8	9	10	11	12	13	-	6 Do, Ha. 7 Do, Ha, Sus, IW. 8 passim. 9, 10, 11 frequent. 12 Ha, Sus, IW, SD, Sal. 13 Sal, Nor.
„ sigma ?, *Schlœn.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ Schlœnbachi, *Dav.*	*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2 Dev. 3 frequent.
„ Wiesti, *Quenst.*	-		2	-	-	-	6	-	-	-	-	-	-	-	-	2 Dev. 6 Dev.
Terebratula abrupta ? *Tate*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Bk.
„ arcuata, *Roem.*	*	1	2	3	-	-	6	-	-	-	-	-	-	-	-	1 MB. 2 Dev, Ch, WD, SD. 3 IW. ? 6 Dev. (base).
„ arenosa, *d'Arch.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ biplicata, *Sow.*	*	1	2	3	4	5	6	-	8	-	-	-	-	-	-	1 common. 2 passim. 3 passim. 4 Cam, F, Nor. 5 He, Cam. 6 Dev. 8 SD.
„ capillata, *d'Arch.*	*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ carnea, *Sow.* -	-	-	-	-	-	-	-	7	8	9	10	11	12	13	14	7 IW, Sus. Common from 8 to 14.
„ cuneata, *Westl.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Sal.
„ obesa, *Sow.* -	*	-	2	3	4	-	-	-	-	-	10	-	-	13	14	2 Dev, Dor. 3 F, Sus, Sur, Wilts. 4 Nor. 10 Ha, Sal. 13 Nor. 14 Tr.
„ ovata, *Sow.* -	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 IW. 2 Dev, Dor.
„ semiglobosa, *Sow.*	-	1	2	3	4	5	6	7	8	9	10	11	12	-	-	Common from 1 to 9. 10 WK, Ha, Sus. 11 WK, Ha. 12 Ha, Sus, Sal, SD.
„ „ var. Carteri, *Dav.*	-	-	-	?3	-	-	-	-	-	-	-	-	-	-	-	3 Do.
„ *sexradiata, Sow* (*see* Kingena).																
„ squamosa, *Mant.*	-	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Dev, Ch, WD. 3 common. 4 F, He, Cam, Suf, Nor.
„ sulcifera, *Morris*	-	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 Cam, Is, Nor, Lin, Sp. 4 He, Cam, Suf.
„ tornacensis, *d'Arch.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ Verneuili, *d'Arch.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.

SPECIES.	Found in Selbornian.	Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	*	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zcne of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
BRACHIOPODA—Cont.																
Terebratella Menardi, *Lam.*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 De. 2 Dev, Ch.
" oblonga, *Sow*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
" pectita, *Sow.*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 IW, MB. 2 Dev, Dor
Terebratulina gracilis, *Schloth.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
" Gisei, *Hag.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
" nodulosa, *Eth*	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	3 F, Cam. 4 Cam, Bur, Hun, Dev, Sp.
" lata, *Eth.* -	-	-	-	-	-	-	6	7	8	9	-	-	-	-	-	Common in 6 and 7. 8 Lin. 9 WK.
" striata, *Wahl.*	*	1	?	3	4	5	6	7	8	9	10	11	12	13	14	Common throughout except in 2.
" triangularis, *Eth.*	*	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 E, MB, Cam, Be. 3 IW, Cam, Nor. 4 Nor.
" Rowei, *Kitchin.*	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11 Mar, Sus, SD. 12 Sus, Sal, SD.
Terebrirostra lyra, *Sow.* -	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Dev.
Thecidium vermiculare, *Schloth.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
" Wetherelli, *Morris.*	-	1	-	-	-	-	-	-	8	9	10	11	12	13	-	1 Cam. LC. Guildford and Pewsey. 8 IW. 10 common. 11 Ha, SD. 12 Ha, SD. 13 Sal.
" sp. - - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Trigonosemus elegans, *Kœnig.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	13	14	13 Nor. 14 Tr.
" incertus, *Dav.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev, Ch.
" pulchellus, *Nilss.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
BRYOZOA.																
Cyclostomata.																
Actinopora (*see* Apsendesia).																
Alecto (*see* Stomatopora).																
Apsendesia diademoides, *d'Orb.* -	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Mid.
" gaudryana, *d'Orb.* -	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
" papyracea, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" (Act.) Brongniarti, *Edw.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
Atagma Lonsdalei, *Greg.* (=A. papularia, *Lons.* non *Mich*).	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	LC, Sussex. 11 Mar.
Berenicea acanthina, *Greg.* -	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Ct.
" Canni, *Greg.* -	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" clementina, *d'Orb.*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
" confluens, *d'Orb.*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
" *congesta*, *Vine* non *d'Orb.* (*see* polystoma).																
" contracta, *Seeley*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
" disciformis, *Hag.*	-	-	-	-	-	-	-	-	-	9	-	-	-	13	14	9 Ct. 13 Nor. 14 Tr.
" *echinata*, *d'Orb* (*see* B. papillosa).																
" gracilis, *Edw.* -	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Ct
" *grandis*, *d'Orb.* (*see* B. papillosa).																

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
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BRYOZOA—Cont.																
Cyclostomata.—Cont.																
Berenicea Hagenovi, *Reuss* non *Vine*.	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" *Hagenovi*, *Vine* (*see* B. contracta).																
" *hunstantonensis*, *Vine* (*see* contracta).																
" Jessoni, *Vine*	*	1	-	-	-	-	-	-	-	9	-	-	-	-	-	1 Cam. 9 Ct.
" lacrimopora, *Nov.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	14	9 Ct. 14 Tr.
" littoralis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" *obelioides*, *Perg.* (*see* B. lacrimopora).																
" *oceanica*, *d'Orb.* (*see* B. papillosa).																
" papillosa, *Reuss*	*	-	-	3	-	-	-	-	8	9	10	11	12	13	-	3 F. 8 Ox. 9 Ct. 10 Ct, Sal, Sus. 11 Sal. 12 Sal. 13 Sal, Nor.
" papyracea, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" phlyctænosa, *Reuss.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Ct, Sal.
" polystoma, *Ræm.*	-	-	-	-	-	-	-	-	-	9	10	11	12	13	-	9 Ct. 10 to 13 Sal.
" regularis, *d'Orb.*	*	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Bicavea dilatata, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Mid.
Bidiastopora (*see* Elea).																
Biflustra carantina, *d'Orb.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Bd.
Bitubigera cribriformis, *Vine.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Cavaria ramosa, *Hag.*	-	-	-	-	-	-	-	-	-	9	-	11	12	-	-	—
Cavarinella (*see* Cavaria).																
Cellulipora ornata, *d'Orb.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Ceriopora ramulosa, *Mich.*	-	-	2	-	-	-	-	-	-	-	10	11	12	-	-	2 Dev. 10 Ha, IW. 11 Ha. 12 Ha, IW.
" spongites ? *Goldf.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Claviclausa clava (*see* Clausa heteropora).																
Clausa francquana, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Ct.
" globulosa, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	10	-	12	13	-	9 Ct, Dev. 10 Sur, IW. 12 Sal. 13 Sal.
" heteropora, *d'Orb*	-	-	-	-	-	-	-	-	-	9	10	11	12	-	-	9 Ct. 10 Mid. 11 Ha 12 Ha.
" irregularis, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	14	(*Heteropora crassa Hag.*) 12 Sal. 14 Tr.
" *micropora*, *d'Orb.* (*see* heteropora).																
" *obliqua*, *d'Orb.* (*see* heteropora).																
" variabilis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" Wrighti, *Greg.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Ct.
Clinopora costulata, *Marss.*	-	-	-	-	-	-	-	-	-	9	-	-	12	-	-	9 Ct. 12 Sal.
" lineata, *Beissel*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" spinigera, *Greg.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Charing detritus.
" striatopora, *Vine*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Clypeina tubæformis, *Lonsd.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Dover.
Crisina cenomana, *d'Orb.*	-	1	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Kent.
" *elegans*, *d'Orb.* (*see* unipora).																
" Gamblei, *Greg.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" marginata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 WK
" *papyracea* (*see* Retecrisina).																

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS
	* Found in Selbornian.	1 Chloritic Marl (Stauronema)	2 Devon Cenomanian, &c.	3 Chalk Zone of Am. varians.	4 Zone of Hol. subglobosus.	5 Zone of Act. plenus.	6 Zone of Rhynch. Cuvieri.	7 Zone of Terebratulina.	8 Zone of Hol. planus.	9 Z. of Mic. cortestudinarium.	10 Zone of Mic. coranguinum.	11 Zone of Marsupites.	12 Zone of Act. quadratus.	13 Zone of Bel. mucronata.	14 Zone of Ostrea lunata.	
BRYOZOA—Cont.																
Cyclostomata—Cont.																
Crisina subgracilis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Ct, Mid.
„ unipora, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Ct.
Desmepora semicylindrica, *Lonsd.*	*	-	-	-	-	-	-	-	8	9	-	-	12	-	-	8 Do, W K. Dev. 9 Ct. Sur. 12 Sal.
Diastopora auricularis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ escharoides, *ich.*	*	1	-	-	-	-	-	-	-	9	-	-	-	-	-	1 MB. 9 Ct.
„ *megapora, d'Orb.* (*see* tubulosa).																
„ mutata, *Perg.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ *oceani* (*see* Reptelea).																
„ *papyracea, d'Orb.* (*see* mutata).																
„ Sowerbyi, *Lonsd.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Sur. 10 Sur.
„ *tubulus, d'Orb.* (*see* escharoides).																
„ tubulosa, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ (*see also* Berenicea).																
Discosparsa simplex, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Domopora clavula, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Mid.
Elea lamellosa, *d'Orb.*	*	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ sp.	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 Sus.
Entalophora *alternata, d'Orb.* (*see* E. virgula).																
„ *cenomana, d'Orb.* (*see* Spiropora).																
„ *clavata, d'Orb.* (*see* E. echinata).																
„ cretacea, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ echinata, *Reuss*	-	-	-	-	-	-	-	-	8	9	10	-	-	-	-	8 Bd. 9 Ct. 10 Mid.
„ Gamblei, *Greg.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ geminata, *Hag.*	-	-	-	-	-	-	-	-	8	9	-	-	-	-	-	8 Bd. 9 Ct.
„ gigantopora, *Vine*	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 Kent.
„ horrida, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ *linearis, d'Orb.* (*see* E. echinata).																
„ madreporacea, *Goldf.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	14	9 Ct. 14 Tr.
„ *obliqua, d'Orb.* (*see* Clausa heteropora).																
„ Pergensi, *Greg.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Ct.
„ *proboscidea, Edw.* (*see* virgula).																
„ ramosissima, *d'Orb.*	*	-	-	-	-	-	-	-	-	9	10	-	12	-	-	9 Sus. 10 Sus. 12 Sal.
„ *raripora d'Orb* (*see* virgula)																
„ *santonensis, d'Orb.* (*see* virgula).																
„ *subgracilis, d'Orb.* (*see* virgula).																
„ *subregularis, d'Orb.* (*see* madreporacea)																
„ *variegata, d'Orb.* (*see* virgula).																
„ virgula, *Hag.*	*	1	-	-	-	-	-	-	8	9	10	-	12	13	14	1 Cam. 8 Bd. 9 Ct. 10 Sur, Mid. 12 Sal. 13 Nor. 14 Tr.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
BRYOZOA—Cont.																
Cyclostomata—Cont.																
Epidictyon *plumatus, Lonsd.* (*see* Siphonio-typhlus)																
„ tenue, *Hag.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Fasciculipora cretacea, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct. Dev.
„ reticulata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Filisparsa ornata, *Reuss*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
„ reticulata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Foricula aspera, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Hammia pustulosa, *Goldf.*	*	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 Sus.
Heteropora (*see* Clausa and Sparsicavea).																
Homœosolen aculeatus, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	[Truncatula.]
„ alternatus, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	Do.
„ carinatus, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	Do.
„ ramulosus, *Lonsd.*	-	-	-	-	-	-	-	-	8	9	10	-	-	-	-	9 Sus, Dev. 10 Mid.
„ sp.	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	—
Hornera carinata, *Reuss*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Chalk detritus.
Idmonea alipes, *Greg.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ cenomana, *d'Orb.*	-	1	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ cristata, *Meun. & Perg.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ subcylindrica *Rœmer.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Sus.
„ *triangularis* (*see* cenomana; *see also* Retecavea).																
Inversaria laminata, *Greg.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Lansdown, Kent.
„ tuberosa, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 SD.
Laterotubigera (*see* Spiropora.																
Lichenopora irregularis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ urnula, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	[Bicavea.] 9 Ct.
Marginaria Romeri, *Lonsd.*	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 Mar.
Meliceritites angulosa, *d'Orb*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ Dollfussi, *Perg.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ *gracilis, Marss.* (*see* M. angulosa).																
„ Lonsdalei, *Greg.*	-	-	-	-	-	-	-	-	8	9	10	11	12	-	-	8 Do. 9. Ct 10 Sur. 11 Mar. 12 Sal.
„ parviarmata, *Greg.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ propinqua, *Marss.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ semiluna, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ semiclausa, *Mich.*	-	1	-	-	-	-	-	-	-	9	-	-	12	13	-	1 MB. 9 Ct. 12 Sal. 13 Sal.
„ undata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Ct.
Multinodelea tuberosa (*see* Inversaria)																
Nodelea durobrivensis, *Greg.*	-	-	-	-	-	-	-	-	-	9	10	-	-	13	-	9 Ct. 10 Ct. 13 Sal.
Petalopora costata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Ct.
„ pulchella, *Lonsd.*	*	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct, Sus.
Proboscina alternata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ angustata, *d'Orb.*	*	1	-	-	-	-	-	-	-	9	10	11	-	-	-	1 Cam. 9 Ct. 10 Sur. 11 Mar.
„ anomala, *Reuss*	-	-	-	-	-	-	-	-	-	9	10	-	12	-	-	9 Ct. 10 Ct, EK. 12 Sal.

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BRYOZOA—cont.																
Cyclostomata.—Cont.																
Proboscina bohemica, *Novak*	*	–	–	–	–	–	–	–	–	9	–	–	12	–	–	9 Ct. 12 Sal.
,, cornucopiæ, *d'Orb.*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct.
,, crassa, var. francorum, *Perg.*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct.
,, ,, var. elevata, *Greg.*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct.
,, ,, var. alectodes, *Greg.*	–	–	–	–	–	–	–	–	–	9	10	–	–	–	–	9 Ct. 10 Sus.
,, *dilatata, var. cantabrigiensis, Vine* (*see* hunstantonensis).																
,, elevata, *d'Orb.*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct.
,, fasciculata, *Reuss*	–	–	–	–	–	–	–	–	–	9	10	–	–	–	–	9 Ct. 10 Sus.
,, flexuosa, *Vine*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 Sa
,, gigantopora, *Vine*	*	1	–	–	–	–	–	–	–	9	–	–	12	13	–	1 Cam. 9 Ct. 12 Sal. 13 Sal.
,, hunstantonensis, *Vine.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
,, marginata, *d'Orb.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 Sal.
,, parasitica, *Hag*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct.
,, radiolitorum, *d'Orb.*	–	–	–	–	–	–	–	–	–	9	10	–	–	–	–	9 Ct. 10 Kent.
,, ramosa, *Edw.*	*	–	–	–	–	–	–	–	8	9	10	11	12	13	14	8 Ox. 9 Ct, Sur, Sus, BK. 10 He. WK. 11 Mar. 12 Sus. 13 Sal. 14 Tr.
,, *rugosa, d'Orb.* (*see* P. augustata)																
,, sarthacensis, *Perg.*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct.
,, *Wetherelli, Morris* (*see* P. ramosa).	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*Diastopora Wetherelli Lonsd.*
Pustulipora pustulosa, Goldf. (*see* Hammia).																
,, *pustulosa, Lonsd.* (*see* Meliceritites Lonsdalei).																
Radiopora tuberculata	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 MB.
,, ornata, *d'Orb.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
Reptelea *lamellosa, d'Orb.* (*see* R. parasitica).																
,, oceani *d'Orb.*	–	–	–	–	–	7	–	–	–	–	–	–	–	–	–	7 SD.
,, parasitica, *Hag.*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct.
Reptoceritites Rowei, *Greg.*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct.
Reptomulticava *collis, Vine.* (*see* Berenicea confluens).																
,, favus, *Seeley.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
,, flabellum, *d'Orb.*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct (teste Gamble).
,, irregularis, *d'Orb.*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct, Do.
,, mammilla, *d'Orb.*	*	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct.
,, mammillata, *d'Orb.*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct.
,, simplex, *d'Orb.*	*	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct. (teste Gamble).
,, radiata, *Vine.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
Reptomulticlausa papularia, *Mich.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
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BRYOZOA - Cont.																
Cyclostomata—Cont.																
Reptomultisparsa congesta, *Reuss.*	-	1		-		-					10		-	-	-	**1 Cam. 10 Sur.**
„ *fecunda, Vine.* (*see* congesta).																
„ megalopora, *Vine.*	-	1		-		-					-		-	-	-	**1 MB, Cam.**
„ Rowei, *Greg.*	-	-		-		-				9	-		-	-	-	**9 Ct, Sus.**
„ Sowerbyi, *Lonsd.*	-	-		-		-				9	10		-	-	-	**9 Sur. 10 Sus.**
Reptotubigera (*see* Proboscina).																
„ *ramosa, d'Orb.* (*see* Prob. radiolitorum).																
„ *ramosa, Vine.* (*see* Prob. cornucopiæ).																
„ *serpens, d'Orb.* (*see* Prob. radiolitorum).																
Retecavea *communis d'Orb.* (*see* R. cretacea).																
„ cretacea, *Edw.*	-	-		-		-					-		12	13	14	**12 Ha. 13 SD. 14 Tr.**
„ pseudodisticha, *Hag.*	-	-		-		-				9	10		-	-	-	**9 Ct. 10 Ct.**
Retecrisina obliqua, *d'Orb.*	-	-		-		-				9	-		-	-	-	**9 Ct, Sus.**
„ papyracea, *d'Orb.*	-	-		-		-			8	9	10		-	-	-	**8 IW. 9 Ct. 10 Ct.**
Reticulipora *complanata, Marss.* (*see* Reticrisina papyracea).																
„ contingens, *Lonsd.*	-	-		-		-					10		-	13	-	**10 Sur, Sus. 13 Nor.**
„ *obliqua, d'Orb.* (*see* Retecrisina).																
„ *papyracea, d'Orb.* (*see* Retecrisina).																
Semicea (*see* Reptelea).																
Semicytis ? disparilis, *d'Orb.*	-	-		-		-				9	-		-	-	-	**9 Ct.**
„ fenestrata, *d'Orb.*	-	-		-		-				9	-		-	-	-	**9 Ct.**
„ rugosa, *d'Orb.*	-	-		-		-				9	-		-	-	-	**9 Ct, Sus.**
Semielea Reussi, *Perg.*	-	-		-		-				9	-		-	-	-	**9 Ct.**
Semimulticava meudonensis, *d'Orb.*	-	-		-		-					-		-	-	14	**14 Tr.**
Semimultelea gradata, *d'Orb.*	-	-		-		-				9	-		-	-	-	**9 Ct.**
Siphoniotyphlus plumatus, *Lonsd.*	-	1		-		-				9	-		12	13	-	**1 Cam. 9 Ct. 12 Sal. 13 Sal.**
„ tenuis, *Greg.*	-	-		-		-				9	-		-	-	14	**9 Ct. 14 Tr.**
Sparsicavea carantina, *d'Orb.*	*	-		-		-				9	10		12	-	-	**9 Ct. 12 He.**
„ *francqana, d'Orb.* (*see* carantina).																
„ reticulata, *Marss.*	-	-		-		-					-		-	-	14	**14 Tr.**
„ Wrighti, *Greg.*	-	-		-		-					10		-	-	-	**? 10 Sur.**
Spiropora *cenomana, d'Orb.* (*see* macropora).																
„ macropora, *d'Orb.*	*	-		-		-					10		-	13	-	**9 Ct. 10 Ct. 13 SD.**
„ „ var. Jessoni, *Vine*	-	1		-		-					-		-	-	-	**1 Cam.**

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
BRYOZOA—Cont.																
Cyclostomata—Cont.																
Spiropora macropora var. micropora, *Vine*	-	1	-	-	-	-	-	-	-	9	-	-	-	-	-	1 MB.
" verticillata, *Goldf.*	-	-	-	-	-	-	-	-	-	9	10	-	-	13	14	9 Ct. 10 Ct. 13 Sus 14 Tr.
Stomatopora divaricata, *Rœm.*	*	-	-	-	-	-	-	-	-	9	10	11	12	13	-	9 Ct. 10 Sur, Sal 11 Sal. 12, 13 Sal.
" calypso, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" gallica, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" gracilis, *Edw.*	*	-	-	-	-	-	-	-	-	9	10	11	12	13	-	9 Ct, Sur. 10 Ct, Sur, Sal. 11. 12 Sal. 13 Nor.
" *graciliformis, Vine,* (*see* granulata).																
" granulata, *Edw.*	*	1	-	-	-	-	-	-	8	9	10	11	12	13	14	1 MB, Cam. 8 Ox. 9 Ct. 10 common. 11 Sal. 12 Sus, Sal. 13 Nor. 14 Tr.
" *linearis, d'Orb.* (*see* granulata.)																
" *longiscata, d'Orb.* (*see* gracilis).																
" *pedicellata, Marss.* (*see* gracilis).																
" *ramea, Lonsd.* (*see* granulata).																
" *ramea, Blainv.* (*see* Proboscina ramosa).																
" *ramea, Vine* (*see* gracilis).																
" spicea, *Greg.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Sulcocava costulata, *Marss.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
" cristata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" gracilis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" *sulcata, Vine* non *d'Orb.* (*see* cristata).																
Truncatula alternata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Sur. 10 Mid
" subpinnata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-		-	-	-	9 Ct.
" tetragona, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Tubulipora chathamensis, *Vine.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Unitubigera (*see* Berenicea).																
Cheilostomata.																
Cellaria cactiformis, *d'Orb*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Sal.
" insequalis, *d'Orb.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8Bd.
Cribrilina brevis, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Sal.
" flabellata, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	11	12	13	-	11 Sal. 12 Sal. 13 Sal.
" fragilis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9Ct.
" horrida, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Sal.
" linearis, *Vine*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" nitidiformis, *Vine*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" obliqua, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" pygmæa, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	11	12	-	-	9 Ct. 11 Sal. 12 Sal.
" radiata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
" sp.	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sus.
Coscinopleura elegans, *Hag.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	1 Chloritic Marl (Stauronema)	2 Devon Cenomanian, &c.	3 Chalk Zone of Am. varians.	4 Zone of Hol. subglobosus.	5 Zone of Act. plenus.	6 Zone of Rhynch. Cuvieri.	7 Zone of Terebratulina.	8 Zone of Hol. planus.	9 Z. of Mic. cortestudinarium.	10 Zone of Mic. coranguinum.	11 Zone of Marsupites.	12 Zone of Act. quadratus.	13 Zone of Bel. mucronata.	14 Zone of Ostrea lunata.	
BRYOZOA—Cont.																
Cheilostomata—Cont.																
Defrancia Brongniarti, *Edw.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ Eudesi, *d'Orb.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Discocytis Eudesi, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Discoflustrellaria doma, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11 Sal. 12 Sal.
„ clypeiformis *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Eschara Aceste, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sus.
„ Acis, *d'Orb.*	-	-	-	-	-	-	-	7	8	9	-	-	12	-	14	7 Dev. 8 Do, Dev. 9 Do, Sus. 12 Sus, Sal. 14 Tr.
„ cancellata, *Goldf.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 WK.
„ Claudia, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ Cleon, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ Clio, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ Cybele, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ cypræa *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	13	-	12 Sal. 13 Sal.
„ Danaë, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	12	13	-	9 Ct. 12 Sal, Sus. 13 Sal.
„ delarneana, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
„ disticha, *Goldf.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 WK.
„ galeata, *Hag.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ Lamarcki, *Hag.*	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	7 Dev.
„ Lonsdalei, *Edw.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
„ neustriaca, *Mich.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ pyriformis, *Goldf.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 WK.
„ rimosa, *Marss.*	-	-	-	-	-	-	-	-	-	-	-	11	12	13	-	11-13 Sal.
„ royana, *d'Orb.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Bd.
„ sexangularis, *M.Edw.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Escharina inelegans *Lonsd.*	-	-	-	-	-	-	-	-	8	-	10	-	12	-	-	8 SD. 10 Sus. 12 Ha, Sus.
Escharinella baculina, *d'Orb.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Bd.
Flustrellaria (*see* Onychocella)																
Hippothoa (*see* Membranipora).																
Homolostega erecta, *Hag.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ nonna, *Hag.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ pavonia, *Hag.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	14	13 Nor. 14 Tr.
„ vespertilio, *Hag.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	14	13 Nor. 14 Tr.
Lunulites cretaceus, *Defr.*	-	-	-	-	-	-	-	-	-	9	10	-	12	13	14	9 Ct. 10 Ha, IW. 12 Ha Sal. 13 Sal. 14 Tr.
„ rosaceus, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
Membranipora Argus, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ arborea, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	10	-	12	-	-	(*Semieschara*). 10 EK. BK. 12 Sus.
„ clathrata, *Reuss.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
„ confusa, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ dispersa, *Marss.*	-	-	-	-	-	-	-	-	-	9	-	-	12	-	14	(*Hippothoa*). 9 Ct. 12 Sal. 14 Tr.
„ dumerilla, var.	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
„ elegans, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	(*Hippothoa*). 9 Ct.
„ elliptica, *Hag.*	-	-	-	-	-	-	-	-	-	9	-	11	12	13	-	9 Ct. 11-13 Sal.
„ granulosa, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ irregularis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Ct. 10 Sal.
„ marginata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct
„ megapora, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
BRYOZOA—Cont.																
Cheilostomata—Cont.																
Membranipora monilifera, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ normaniana, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 EK. BK.
„ ovalis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ pauperata, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	(*Biflustra.*) 12 Sal.
„ parisiensis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	(*Cellepora.*) 9 Ct.
„ pulchella, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ pygmæa, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ tuberosa, *Nov.*	-	-	-	-	-	-	-	-	-	-	-	11	12	13	-	11 Sal. 12 Sal. 13 SD.
„ velamen, *Goldf.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ sp. - -	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Dev.
Micropora confluens, *Reuss.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
„ delarnea, *d'Orb.* -	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
„ hippocrepis, *Goldf.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
„ intricata, *Lonsd.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct, Sus.
„ oceana, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ rimosa, *Marss.*	-	-	-	-	-	-	-	-	-	9	-	-	12	-	-	9 Ct. 12 Sal.
„ Rœmeri, *Lonsd.*	-	-	-	-	-	-	-	-	-	9	-	-	12	-	-	9 Ct. 12 Sal.
„ simplex, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ sp.	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Microporella antiquata, *Vine.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Onychocella camerata, *Hag.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ francquana, - *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ granulosa, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Mid.
„ koninckiana *Hag.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ Lamarcki, *Hag.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	14	10 Mid. 14 Tr.
„ parisiensis, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
Pachydera grandis, *Marss.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
Pavolunulites elegans, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Planicellaria oculata, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
Porina cincta, *Reuss* - -	-	-	-	-	-	-	-	-	-	9	-	-	12	-	-	9 Ct. 12 Sal.
„ filiformis, *d'Orb.* -	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ filograna, *Goldf.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ pustulosa, *Marss.* -	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11 Sal. 12 Sal.
Quadricellaria excavata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Reptolunulites angulosa, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Semicytis disparilis, *d'Orb.* -	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ fenestrata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ rugosa, *d'Orb.* -	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct, Sus.
Semieschara arborea (*see* Membranipora).																
Semiescharipora galeata, *Beiss.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
Stichopora clypeata, *Hag.* -	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Supercytis digitata, *d'Orb* -	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Systenostoma asperulum, *Marss.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
Unicytis falcata, *d'Orb.* -	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
Vincularia abscondita, *Marss*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ areolata, *d'Orb.* -	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.

SPECIES.	Found in Selbornian. *	Lower Chalk. Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Mid'le Chalk. Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Upper Chalk. Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	LOCALITIES AND REMARKS.
BRYOZOA—Cont.																
Cheilostomata—Cont.																
Vincularia Bronni, *Reuss.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
„ cactiformis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ cretacea, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct. 10 Wk.
disparilis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	10	11	12	-	-	9 Ct. 10 Do, Sus. 11 Sus, Mar. 12 Sus.
„ exsculpta, *Marss.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ excavata, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
„ francqana, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	13	-	12 Sal. 13 Sal.
„ gaudryana, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ch.
„ inæqualis, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
„ leda, *d'Orb.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Do.
„ oculata, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 WK.
„ perangusta, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 WK.
„ regularis, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	12	13	-	9 Ct. 12 Sal. 13 Sal.
„ santonensis, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	10	-	12	-	-	10 WK. 12 Sus.
„ simplex, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
„ strumulosa, *Marss.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ undata, *d'Orb.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Ct.
„ sp.	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Mid.
CRUSTACEA																
Brachyura.																
Callianassa Archiaci	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
„ sp.	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Cyphonotus incertus, *Bell*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Ch.
Dianlax Oweni, *Carter*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC. Do. and Maidstone.
Eucorystes Carteri, *Bell*	*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Necrocarcinus Bechei, *Desl.*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Dev.
„ Woodwardi, *Bell.*	*	-	2	3	4	-	-	-	-	-	-	-	-	-	-	2 Dev. 3 IW. 4 Cam.
Palæocorystes Normanni, *Bell.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 F, IW.
„ Stokesi, *Mant.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 F.
Plagiophthalmus oviformis, *Bell.*	*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Platypodia Oweni, *Woodw.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Sussex.
Macrura.																
Glyphæa cretacea, *McCoy*	*	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 He, Cam.
Enoploclytia brevimana, *McCoy.*	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 Cam.
„ Imagei, *Mant.*	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 Cam.
„ Leachi, *Mant.*	-	-	-	-	4	-	-	7	8	9	10	11	-	-	-	4 WK, Sus. 7 Sur, Ha, Sus. 8 Do, Sus. 9, 10, 11 common.
„ sussexiensis, *Mant.*	-	-	-	3	4	5	-	7	-	-	-	-	-	13	-	3 F, Sus. 4 Sur, WK, Sus, He. 5 Sus. 7 Sus, Ha. 13 Nor.
Hoploparia sp.	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Sus. 3 F.
Meyeria Willetti, *H. Woodw.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 IW, and Chalk, Lewes.
Palæga Carteri, *H. Woodw.*	-	-	-	3	4	-	-	-	8	-	-	-	-	-	-	3 F, Bd, NW, Ox. 4 Bd, Cam. 8 NW.
Palæastacus *Dixoni, Bell* (*see* Enoploclytia sussexiensis).																

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
CRUSTACEA—Cont.																
Cirripedia.																
Brachylepas cretacea, *H. Wdw.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 SD, Nor.
Loricula pulchella, *Sow.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
Pollicipes acuminatus, *Darw.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	LC Norf.
" Angelini, *Darw.*	–	–	–	–	–	–	–	–	–	–	–	–	12	13	–	12 Sal. 13 Nor.
" Bronni, *Rœmer*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 MB.
" *cancellatus*, (see Brachylepas)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
" fallax, *Darw.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	14	13 Sal, SD, Nor. 14 Tr.
" *lævis* (*see* glaber)																
" glaber, *Rœm.*	*	1	–	3	4	–	–	7	8	–	10	11	12	–	–	1 Cam. 3 F, He. 4 Cam, Nor. 7 Sus. 8 Bd, IW. 10 Mar, WK Sus. 11 Mar, Ha, Sus. 12 Sus, Ha, IW, Sal.
" striatus, *Dar.*	–	–	–	–	–	–	–	7	–	–	10	–	12	13	–	7 Do. 10 Sal. 12 Ha, Sal. 13 Nor.
" unguis, *Sow.*	*	1	–	3	4	–	–	–	–	9	10	–	–	–	–	1 Cam. 3 Nor. 4 Nor. 9 WK. 10 WK.
" sp.	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 F.
Pyrgoma cretacea, H. Woodw (see Brachylepas)																
Scalpellum angustum, *Darw.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	loc. unknown.
" arcuatum, *Darw.*	*	1	–	3	–	–	–	–	–	–	10	–	–	–	–	1 Cam. 3 F. 10 Sur.
" Darwinianum, *Bosq.*	–	–	–	–	–	–	–	–	–	–	–	–	12	13	–	12 Sal. 13 Sal.
" fossula, *Darw.*	–	–	–	–	–	–	–	–	–	9	10	11	12	13	14	9 Do, Sus. 10 Do, Sus. 11 Mar, Sus. 12 Sal, Ha, Sus. 13 Nor, Sal, SD. 14 Tr.
" hastatum, *Darw.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F.
" lineatum, *Darw.*	*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	LC. Maidstone.
" maximum, *Sow.*	–	–	–	–	–	–	–	7	8	9	10	11	12	13	–	7 Do. 8 Do. 9 Do. Sus. 10, 11, 12 common. 13 Sal, SD, Nor.
" quadricarinatum, *Reuss.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 Sal.
" semiporcatum, *Darw.*	–	–	–	–	–	–	–	–	8	–	–	–	12	13	–	8 IW. 12 Ha, Sal. 13 IW, Sal.
" trilineatum, *Darw.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F.
" tuberculatum, *Darw.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Chalk of Kent.
" sp.	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	5 Bd.
Verruca prisca, *Darw.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
Ostracoda.																
Bairdia harrisiana, *Jones*	*	1	–	3	–	–	–	–	8	–	10	–	–	13	–	1 Cam. 3 Cam. 8 Bd. 10 WK. 13 Nor.
" " var. amplior, *J. & H.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
" subdeltoidea, *Münst.*	*	1	–	3	4	5	–	–	8	9	10	11	–	13	–	1 Cam. 3 Be. Cam. 4 He, 5 Do, 8 to 13, Common.
Bythocypris Brownei, *J. & H.*	–	1	–	3	–	5	–	–	8	–	–	–	–	–	–	1 Cam, 5 Cam, 3 Do, 8 Bd.
" reussiana, *J. & H.*	*	1	–	–	–	–	–	–	–	–	10	–	–	–	–	1 Cam, 10 Ct.
" roemeriana, *J. & H.*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Bd.
" silicula, *Jones*	*	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Bd.
" " var. minor, *J. & H.*	*	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Bd.
" simulata, *Jones*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Charing detritus.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
CRUSTACEA—Cont.																
Ostracoda—Cont.																
Cythere bosquetiana, *Jones*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Charing detritus.
,, harrisiana, *Jones*	*	1	–	3	–	–	–	–	8	–	10	–	–	–	–	1 Cam. 8 Bd. 10 WK.
,, ,, var, setosa, *J. & H.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
,, gaultina *Jones*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
,, sutuberculata, *Chap.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
,, Koninckiana, *Bosq.*	–	1	–	3	4	–	–	–	–	–	–	–	–	–	–	1 Cam.
Cythereis auriculata, *Cornuel*	*	1	–	3	–	–	–	–	8	–	–	–	–	–	–	1 Cam. 8 Bd.
,, icenica, *J. & H.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
,, ,, var. quadrata, *J. & H.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
,, lonsdaleana, *Jones*	*	1	–	–	–	–	–	–	8	–	–	–	12	13	–	1 Cam. 3 Cam, 8 Bd. 13 Nor.
,, ornatissima, *Reuss*	*	1	–	3	4	–	–	–	8	–	10	–	–	13	–	1 Cam. 4 He. 8 Bd. 10 common, 13 Nor.
,, ,, var. nuda, *J. & H.*	*	1	–	3	–	–	–	–	–	9	10	–	–	13	–	1 Cam. 3 Be. 9 Do. 10 common, 13 Nor,
,, ,, var. paupera, *J. & H.*	*	1	–	3	–	–	–	–	8	9	–	11	–	13	–	1 Cam. 3 Cam. 8 Bd. 9 Do. 11 common, 13 Nor.
,, ,, var. radiata, *J. & H.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
,, ,, var. reticulata, *J. & H.*	*		–	3	–	–	–	–	8	–	10	–	–	13	–	1 Cam. 3 Be. 8 Bd. 10 common. 13 Nor
,, ,, var. stricta, *J. & H.*	*	1	–	3	–	–	–	–	8	–	–	–	–	–	–	1 Cam. 3 Be. 8 Bd.
,, quadrilatera, *Rœm*	*	1	–	3	–	–	–	–	8	–	–	–	–	13	–	1 Cam. 3 Be, Do. 8 Bd. 13 Nor.
spinicaudata, *J. & H.*	–	–	–	–	–	–	–	–	8	–	–	–	–	13	–	8 Bd. 13 Nor.
,, triplicata, *Rœm.*	*	1	–	3	4	–	–	–	8	–	–	–	–	–	–	1 Cam. 3 Be. Cam. 4 He. 8 Bd.
,, tuberosa, *J. & H.*	–	1	–	–	–	–	–	–	8	–	–	–	–	13	–	1 Cam. 8 Bd. 13 Nor.
,, ,, var. symmetrica.	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
,, Wrighti, *J. & H.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
Cytheridea perforata, *Rœm.*	*	1	–	3	4	–	–	–	8	–	–	–	–	13	–	1 Cam. 3 Be, Do. 4 He. 8 Bd. 13 Nor.
Cytheropteron alatum, *Bosq.*,	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Cam.
var. robusta, *J. & H.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
,, ,, var. fortis, *J. & H.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
,, ,, var. cornuta, *Bosq.*	*	–	–	–	–	–	–	–	8	–	10	–	–	13	–	8 Bd. 10 (*see* p. 325) 13 Nor.
,, concentricum, *Reuss.*	*	1	–	3	–	–	–	–	8	–	–	–	–	13	–	1 Cam. 3 Be, Cam, Do. 8.
,, ,, var. virginea, *Jones.*	–	1	–	–	–	–	–	–	8	–	10	11	–	13	–	1 Cam. 10 WK. 11 Mar, Sus, Dor, 13 Nor.
,, cuspidatum, *J. & H.*	*	1	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
,, ,, var. tricuspidata, *J. & H.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
,, pedatum, *Marss.*	–	–	–	–	–	–	–	–	8	–	–	–	–	13	–	8 Bd. 13 Nor.
,, ,, var. salebrosa, *J. & H.*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Bd.
,, Sherborni, *J. & H.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
,, sphenoides, *Reuss*	–	1	–	–	–	–	–	–	8	–	–	–	–	–	–	1 Cam. 8 Bd.
,, umbonatum, *Will.*	*	–	–	3	–	–	–	–	–	9	–	11	–	13	–	3 Do. 9 Do. 11 Mar, Sus, Dor. 13 Nor.
,, ,, var. acanthoptera, *Marss*	–	1	–	–	–	–	–	–	8	–	–	–	–	–	–	1 Cam. 8 Bd.
,, ,, var. longispinata, *J. & H.*	*	1	–	–	–	–	–	–	–	–	–	–	–	13	–	1 Cam. 13 Nor.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
CRUSTACEA—Cont.																
Ostracoda—Cont.																
Cytherella mantelliana, *Jones*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	Ch. detr. Charing.
„ **Muensteri,** *Rœm.*	-	1	-	3	4	-	6	-	8	9	10	11	-	-	-	1 Cam. 3 Be, Cam 8 Do. 8 Bd. 9 Do. 10 common, 11 Mar, Sus, Dor. 13 Nor.
„ **obovata,** *J. & H.*	-	1	-	3	4	-	-	-	8	-	10	11	-	-	-	1 Cam, 3 He, 4 He, 8 Sus, Bd, 11 Mar, Sus, Dor. 13 Nor.
„ **obliquirugata,** *J. & H.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Chalk of Winchester.
„ **ovata,** *Rœmer*		1	-	3	-	-	6	-	8	9	10	11	12	13	-	1 Cam. 3 Be, Do, Cam. 8 Bd, Bk, Ox. 13 Nor.
„ **subreniformis,** *J. & H.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Kent.
„ **williamsoniana,** *Jones.*	*	1	-	3	-	-	-	-	8	9	10	11	-	13	-	1 Cam. 3 Do, Cam, 8 Bd. 9 Do. 10 Do, Sus, He. 13 Nor.
„ „ **var. granulosa,** *Jones.*	*	-	-	-	-	-	-	-	-	9	-	11	-	13	-	9 Do, 11 Mar, Sus Dor. 13 Nor.
„ „ **var stricta**	*	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Macrocypris concinna, *J.&H.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Bd.
„ **muensteriana,** *J. & H.*	*	1	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ **siliqua,** *Jones*	-	1	-	-	-	5	-	-	-	-	-	-	-	-	-	1 Cam. 5 Do.
„ **simplex,** *Chap. J. & H.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Paracypris gracilis, *Bosq.*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
„ **siliqua** *J. & H.*	*	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
Pontocypris bosquetiana, *J.& H.*	*	1	-	3	-	-	-	-	-	-	-	11	-	-	-	1 Cam. 3 Be, Cam. 11 Mar, Sus, Dor.
„ **triquetra,** *Jones*	*	1	-	-	-	-	-	-	-	-	10	-	-	-	-	1 Cam. 10 WK.
Pseudocythere ? simplex, *J. & H.*	*	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
ANNELIDA.																
Ditrupa difformis, *Lam.*	*	-	2	-	4	-	-	-	-	-	-	-	-	13	14	2 Dev. 4 Nor. 13 SD. 14 Trim.
Serpula ampullacea, *Sow.*	*	-	-	3	4	-	-	7	8	9	10	11	12	13	14	3 and 4 common. 7 Do, IW, Dev. 8 Do, Sus, SD. Ox. 9 Do, Sus, WK. 10 to 13 common. 14 Trim.
„ **annulata,** *Reuss*	*	-	-	3	4	-	-	7	-	9	10	11	12	13	-	3 and 4 common. 7 Ha. 9 SD. 10 IW. 12 Ha. 11 to 13 Sal.
„ **antiquata,** *Sow.*	*	-	2	3	4	-	-	-	-	-	-	-	-	-	-	2 Dor. 3 SD, Nor. 4 Cam.
„ **canteriata,** *Hag.*	-	-	-	-	-	-	-	-	-	-		-	-	-	14	14 Trim.
„ **carinata,** *S. Woodw.*	-	-	-	-	-	-	-	-	-	9	-	-	-	13	-	9 WK. 13 Nor.
„ **cincta,** *Goldf.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Sus.
„ **concava,** *Sow.*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 MB.
„ **contracta,** *S. Woodw.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ *filiformis* (*see* plexus).																
„ **fluctuata,** *S. Woodw.*	-	-	-	-	-	-	-	7	8	9	10	11	12	13	14	7 Do, Ha. 8 to 12 common. 13 IW, SD. Nor. 14 Trim.
„ *gordialis*(*see* plexus).																

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	1 Chloritic Marl (Stauronema)	2 Devon Cenomanian, &c.	3 Chalk Zone of Am. varians.	4 Zone of Hol. subglobosus.	5 Zone of Act. plenus.	6 Zone of Rhynch. Cuvieri.	7 Zone of Terebratulina.	8 Zone of Hol. planus.	9 Z. of Mic. cortestudinarium.	10 Zone of Mic. coranguinum.	11 Zone of Marsupites.	12 Zone of Act. quadratus.	13 Zone of Bel. Mucronata.	14 Zone of Ostrea lunata.	
ANNELIDA—Cont.																
Serpula granulata, *Sow.*	–	–	–	–	–	–	–	7	8	9	10	11	12	13	14	7 Do. 8 Do, Ox, Bd. 9 to 12 common. 13 IW, SD. Nor. 14 Tr.
„ ilium, *Sow.*	*	–	–	3	–	–	–	7	8	9	10	11	12	13	14	3 IW. 7 Do, Sus. 8 to 12 common. 13 IW. SD. 14 Tr.
„ lituitis, *Defr*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	14	13 Nor. 14 Tr.
„ lumbricus, *Defr.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	14	13 SD, Nor. 14 Tr.
„ macropus, *Sow.*	*	–	–	–	–	–	–	–	8	9	10	11	12	13	14	8 Do. Sus. 9 Do, Sus. WK. 10 EK, Sus. 11 Mar, Sus. 12 Sus. 13 SD. Nor. 14 Tr.
„ obtusa, *Sow.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
„ plana, *S. Woodw.*	?	–	–	–	–	–	6	7	8	9	10	11	12	13	–	6 Do, Sus. 7 Do, Sus. 8 SD. 10 Ha, SD, EK. 11 Mar, Sus. SD. 12 Sus. SD. 13 SD, Nor.
„ planorbis, *Gein.*	–	–	–	–	4	–	–	–	–	–	–	11	–	–	–	4 F. 11 SD.
„ plexus, *Sow.*	*	1	2	3	–	–	6	7	8	9	10	11	12	13	14	1 MB. 2 Dev. 6 Do, Dev. 7 Do, Ha, Sus. 8 Bk, Ox. Common in 9 to 14.
„ proteus, *Sow.*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	
„ pusilla, *Sow.*	–	–	–	–	–	–	–	–	–	–	–	11	–	13	–	11 Sus. 13 Nor.
„ rustica, *Sow.*	*	1	–	–	4	–	–	–	–	–	–	–	–	–	–	1 F. 4 Cam.
„ spirulæa, *Sow.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
„ *septemsulcata* (*see* Ditrupa difformis).																
„ striata *Defr.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
„ subtorquata, *Münst.*	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 Nor.
„ turbinella, *Sow.*	–	–	–	–	–	–	–	–	–	9	10	11	12	13	14	9 Do. 10 to 12 common. 13 IW, SD. 14 Tr.
„ trochiformis, *Hag.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	—
„ umbonata, *Sow.*	*	1	2	3	4	–	–	–	–	–	–	–	–	–	–	1 MB, Cam. 2 Dor. 3 passim. 4 common.
„ vortex, *S. Woodw.*	–	–	–	3	–	–	–	–	–	–	–	–	–	13	–	3 F. 13 Nor.
„ vermes, *Sow.*	*	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dor.
Terebella lewesiensis, *Davies.*	–	–	–	–	–	–	–	–	–	9	10	11	12	13	–	9 WK. 10 Mar, Sur, Mid. 12 Sus. 13 Nor.
ECHINODERMATA.																
Echinoidea.																
Ananchytes (*see* Echinocorys).																
Caratomus rostratus, *Ag.*	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 Wilts. 2 Dev.
„ cf. faba, Ag.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
Cardiaster ananchytis, *Leske*	–	–	–	–	–	–	–	–	8	9	10	–	12	13	14	8 Do. Cam. 9 Do. 10 Nor. 12 Yo. 13 SD. Nor Sal. 14 Trim.
„ cotteauanus, *d'Orb.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Mid. Ch., Dover.
„ fossarius, *Benett*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 IW. (lowest bed.
„ grandis, *Benett*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 Nor.
„ *granulosus, Goldf.* (*see* ananchytis).																

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
ECHINODERMATA—Cont.																
Echinoidea—Cont.																
Cardiaster *pillula*, *Lam.* (*see* Offaster).																
" pygmæus, *Forbes*	-	-	-	-	-	-	6	7	-	9	-	-	-	-	-	6 passim. 7 Do, Sus, Dev. 9 Do.
" sp. - - -	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 I W.
" sp. nov. - -	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
" *excentricus* (*see* Infulaster).																
" *major* (*see* Infulaster.)																
" *rostratus*, *Forbes* (*see* Hagenowia).																
" (Stegaster) sp. -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
" Woodwardi, *Seeley*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Catopygus columbarius, *Lam.*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Dev, Ch, Dor.
Cidaris Bowerbanki, *Forbes*	-	1	-	3	4	-	6	7	-	-	-	-	-	-	-	1 Cam. 3 F, Cam Sus. 4 Norf, Cam. 6 Do. 7 Sus.
" Carteri, *Forbes* -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Cam.
" clavigera, *Kœnig* -	-	-	-	-	-	-	-	7	8	9	10	11	12	-	-	7 doubtful. 8 Do, Sus, SD. IW, Dev? 9, 10. 11 passim. 12 Sus, Ha, IW.
" *cretosa*, *Mant.* (*see* subvesiculosa).																
" Dixoni, *Cott.* - -	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 F.
" dissimilis, *Forbes* -	-	1	-	3	4	-	6	7	-	-	-	-	-	-	-	1 Cam IW. 3 passim. 4 Nor, Cam. 6 Ox, Cam. 7 Cam, Dev.
" gradata, *Seeley* - -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam (? = C. vesiculosa).
" hirudo, *Sorig.* - -	-	-	-	-	4	5	6	7	8	9	10	11	12	13	-	4 Cam. 5 Bk. 6 passim. 7 Do, Sus. 8 to 11 common. 12, Sal, Ha, Sus, SD. 13 Sal, SD. IW.
" intermedia, *Wiltsh.* -	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	? 7 Sus.
" Merceyi, *Cott.* - -	-	-	-	-	-	-	-	7	-	-	10	11	-	-	-	7 Bd. 10 Sus. 12 Sus.
" peronata, *Forbes* -	-	-	-	-	-	-	6	7	8	9	10	11	-	-	-	6 Do. 7 Do. 8 Do, Sus. 9 Do, Sus, WK. 10 common. 11 WK, Mar.
" pleracantha, *Ag.* -	-	-	-	3	-	-	-	-	-	-	-	-	-	13	-	3 Lewes, Sur. 13 SD.
" sceptrifera, *Mant.* -	-	-	-	-	-	-	-	-	8	9	10	11	12	13	-	8 Do, Sus, SD, Cam. Frequent in 9 to 13.
" Sedgwicki, *Seeley* -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
" serrata, *Desor* - -	-	-	-	-	-	-	-	-	-	-	-	-	12	13	14	12 NH. 13 SD. IW. 14 Trim.
" serrifera, *Forbes* -	-	-	-	-	-	-	6	7	8	9	10	-	-	13	-	6 Do Ha, Sus, Dev. 7 Do, Sus, Dev. 8 Do, Sus, SD, Dev. 9 and 10 common. 13 SD.
" Sorigneti, *Gein.* -	-	-	-	-	-	-	6	7	-	-	-	-	-	-	-	6 Dev 7 Ha, Dev.
" subvesiculosa, *d'Orb.*	-	-	-	-	-	-	6	7	8	9	10	11	12	13	-	6 SD. 7 Do, Sus. 8 SD. 9 and 10 common. 11 WK, Yo. 12 Sal, Ha, 13 Sal, SD.
" *sulcata*, *Forbes* (*see* hirudo).																
" uniformis, *Sorig.*	*	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 Hun.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
ECHINODERMATA—Cont.																
Echinoidea—Cont.																
Cidaris vesiculosa, *Goldf.*	*	1	2	3	4	-	-	-	8	-	-	-	-	-	14	1 Cam. 2 Dev. 3 F, Hun, Sp. 4 Hun, 8 Cam. 14 Tr.
Codiopsis doma, *Desm.*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Cottaldia Bennettiæ, *Kœnig*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Dev.
Cyphosoma corollare, *Klein*	-	-	-	-	-	-	-	-	8	-	10	11	12	13	-	8 Bd. 10 common. 11 WK, Sal. 12 Sal, SD. 13 SD, Nor.
„ elongatum, *Cott.*	-	-	-	-	-	-	-	-	-	-	-	11	-	13	14	11 Dor. 13 SD. 14 Tr.
„ granulosum, *Goldf.*	-	-	-	-	-	-	6	7	-	9	10	11	-	13	-	6 Do, Dev. 7 Bd. 9 WK. 10 WK. 11 WK. 13 Nor.
„ Kœnigi, *Mant.*	-	-	-	-	-	-	-	-	-	9	10	11	12	13	-	9 WK. 10 to 13 common.
„ magnificum, *Ag.*	-	-	-	-	-	-	6	-	-	9	-	-	12	13	-	6 Do. 9 WK. 13 Nor.
„ princeps, *Desor*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ radiatum, *Sorig.*	-	-	-	-	-	-	6	7	8	9	10	11	12	13	14	6 Do. 7 Do, Sus, Ha. 8, 9, 10, 11 common. 12 Sal, Ha. 13 Sal, SD, 14 Tr.
„ *simplex, Forbes* (*see* radiatum).																
„ spatuliferum, *Forbes.*	-	-	-	-	-	-	-	-	-	-	10	11	12	-	-	10 WK, Ha. 11 WK. 12 Sal.
„ Wetherelli, *Forbes.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	14	10 WK. 14 Tr.
Discoidea cylindrica, *Lam.*	-	1	2	3	4	5	-	-	-	-	-	-	-	-	-	Common from 1 to 5
„ Favrina, *Desor.*	*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2 Dev. 3 F.
„ minima, *Ag.*	-	-	-	-	-	-	6	7	-	-	-	-	-	-	-	6 passim. 8 common.
„ Dixoni, *Forbes*	-	-	-	-	-	-	6	7	-	-	-	-	-	-	-	6 He, Do, Ha, Wilts. 7 common.
„ subuculus, *Klein*	*	1	2	3	4	-	6	-	-	-	-	-	-	-	-	Common in 1 to 4. IW.
Echinobrissus (*see* Nucleolites).																
Echinoconus (*see* Galerites)																
Echinocyphus difficilis, *Ag.*	*	1	2	3	-	-	6	7	-	-	-	-	-	-	-	1 MB. 2 Dev, Ch 3 F. 6 Dev. 7 IW.
„ impressus, *Seeley* (? var. of difficlis)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
„ mespilia, *Woodw.*	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	6 Do.
Echinocorys scutatus, *Leske*, (=vulgaris, *Breyn.*)	-	-	-	-	-	-	-	7	8	9	10	11	12	13	14	Common from 8 to 14 7 Sus (rare).
Echinothuria floris, *Woodw.*	-	-	-	-	-	-	-	-	-	-	10	11	12	-	-	10 Roch.
Epiaster crassissimus, *Defr.*	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2 Dev. 3 F, Hun.
„ *brevis, Desor.* (*see* gibbus).	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
„ gibbus, *Lam.*	-	-	-	-	-	-	-	-	-	9	10	11	-	13	14	9 Do. 10 passim. 11 Mar. 13 Nor. 14 Tr.
„ sp.	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dor.
Galerites abbreviatus, *Desor.*	-	-	-	-	-	-	-	-	-	-	10	-	-	13	14	10 Ha. 13 Nor. 14 Tr.
„ albogalerus, *Leske*	-	-	-	-	-	-	-	-	8	9	10	11	12	-	-	8 SD 9 Sus, SD. 10, 11 passim. 12 Ha, IW.
„ castanea, *Brongn.*	*	1	2	3	-	-	6	-	-	-	-	-	-	-	-	1 MB, IW. 2 Dev, Ch Dor, 3 Lew. 6 Do, He, Dev, Cam.
„ globulus, *Desor.*	-	-	-	-	-	-	6	7	-	-	-	11	12	-	-	6 Do. 7 Do. 11 Ha, 12 WK.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
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ECHINODERMATA.—Cont.																
Echinoidea—Cont.																
Galerites *Rœmeri*, *d'Orb.* (*see* abbreviatus).																
" subrotundus, *Mant.*	–	–	–	–	–	–	6	7	8	9	10	–	?	–	–	6 & 7 passim. 8 Sus. 9 SD. 10 Ha.
Glyphocyphus radiatus, *Hæn.*	*	1	2	3	–	–	6	–	–	–	–	–	–	–	–	1 IW, MB. 2 Dev. 3 F, E, Ha, IW. 6 Do, Sus, Dev.
Goniophorus lunulatus, *Ag.*	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB, Cam 2 Dev.
Hagenowia rostrata, *Forbes*	–	–	–	–	–	–	–	–	–	–	10	11	12	13	–	10 Nor. 11 Sal, Yo. 12 Sal, Yo. 13 Nor.
Hemiaster bufo, *Desor.* -	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 IW. 2 Dev.
" Griepenkerli, *Stromb.*	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 F.
" minimus ? *Ag.* -	*	–	–	3	–	–	6	7	–	–	–	–	–	–	–	3 F. Common in 6 & 7.
" Morrisi, *Forbes* -	–	1	2	3	4	–	–	–	–	–	–	–	–	–	–	1 IW, MB. 2 Dev. 3 F, Sus, IW, Bk. 4 Bd, He, Cam.
Helicodiadema fragile, *Wilt.*	–	–	–	–	–	–	–	–	–	–	–	–	12	13	–	Up. Chalk, Gravesend. 12 Sal. 13 Sal.
Holaster Bischoffi, *Renev.* -	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
" *carinatus*, *Ag.* (*see* lævis).																
" lævis, *de Luc* -	*	1	2	3	–	–	–	–	–	–	–	–	–	–	–	Common in 1 to 3.
" " var. nodulosus, *Goldf.* -	–	–	–	3	4	–	–	–	–	–	–	–	–	–	–	Common in 3 & 4.
" obliquus, *Wright* -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F.
" placenta, *Ag.* -	–	–	–	–	–	–	6	7	8	9	10	–	–	13	–	6 Do. 7 Do, Sus. 8 Ha, SD, Dev, Suf. 9 EK, WK, SD, Dev. 10 WK, Nor. ? 13 Nor.
" planus, *Mant.* -	–	–	–	–	–	–	6	7	8	9	–	–	–	–	–	6 Do. 7 common. 8 passim. 9 Do, WK.
" *rotundus*, *Jukes-Br.* (*see* Offaster sphæricus).																
" subglobosus, *Leske*	*	–	2	3	4	–	–	–	–	–	–	–	–	–	–	2 Dev, Ch, Dor. 3 Sus, Ha, IW, Dor, Lin. 4 passim.
" " var. altus, *Ag.*	*	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB. 2 Dev.
" suborbicularis, *Cott.*	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1 MB. 2 Dev, Dor ?
" trecensis, *Leym.* -	–	1	2	3	4	5	–	–	–	–	–	–	–	–	–	1 MB. 2 Dor. 3 South Cts. 4 passim. 5 Bk.
" *pillula*, (*see* Offaster).																
" *sphæricus* (see Offaster).																
Holectypus bistriatus, *Wright*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev, Ch.
Infulaster excentricus, *Rose*	–	–	–	–	–	–	–	–	–	–	10	11	12	13	–	10 Ha, Cam, Nor, Yo. 12 Sal, Yo. 13 Nor.
" major ? *Desor* (*See also* Hagenowia.)	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 IW.
Micraster *breviporus*, *Ag.* (*see* M. Leskei).																
" Brongniarti, *Héb.*	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	13 IW.
" coranguinum, *Klein*	–	–	–	–	–	–	–	–	–	?	10	11	12	13	14	10, 11 passim. 12 SD, Yo. 13 SD, Nor, Yo. 14 Tr.
" corbovis, *Forbes* -	–	–	–	–	–	–	6	7	8	9	–	–	–	–	–	6 Do. 7 common. 8 common. 9 Cam,

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ECHINODERMATA—Cont.																
Echinoidea—Cont.																
Micraster cortestudinarium, *Goldf.*	-	-	-	-	-	-	-	-	8	9	10	-	-	-	-	8 frequent. 9 passim. 10 Mid, Ha, SD, EK.
„ glyphus, *Schlüter* -	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11 Sur, Ha. 12 Sus.
„ Leskei, *Desm.* -	-	-	-	-	-	-	-	7	8	9	-	-	-	-	-	7 Do, Ha, Dev. 8 passim. 9 WK, Cam.
„ præcursor, *Rowe* -	-	-	-	-	-	-	-	-	8	9	10	-	-	-	-	8 & 9 common. 10 Do, Sus, SD, Mid.
Nucleolites lacunosus, *Goldf.*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Dev.
Offaster pillula, *Lam.* - -	-	-	-	-	-	-	-	-	-	-	10	11	12	13	-	10 Sur, Sus, WK, SD. 11 & 12 passim. 13 IW.
„ sphæricus, *Schlüter*	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	3 Lin, Sp, Hun. 4 Lin, Sp.
Pedinopsis Wiesti, *Wright* -	-	-		-	-	-	-	-	-	-	-	-	-	-	-	2 Ch.
Peltastes Bunburyi, *Forbes* -	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	3 F. 4 Do & Mildenhall.
„ clathratus, *Ag.* -	*	1	-	3	4	-	6	-	-	-	-	-	-	-	-	1 MB. 3 F, IW. 4 F. ? 6 Dev.
„ umbrella, *Ag.* - -	*	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Dev. 3 F, IW. 4 F.
„ Wiltshirei, *Wright* -	*	1	-	-	-	-	-	7	-	-	-	-	-	-	-	1 MB. 7 Ha.
Phymosoma princeps, Hag. (*see* Cyphosoma).																
Pseudodiadema Benettiæ, *Forbes.*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Dev.
„ *Bonei, Forbes.* (*see* Michelini).																
„ Brongniarti, *Ag.*	*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 F.
„ *fragile, Wilt.* (*see* Helicodiadema).																
„ Mackiei, *S.P. Woodw.*	*	1	2	3	-	-	-	-	-	-	-	-	-	-	-	2 Ch, Dev. 3 F.
„ Michelini, *Ag.*	*	-	2	-	4	-	-	-	-	-	-	-	-	-	-	2 Dev. 4 F.
„ Normaniæ, *Cott.*	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	3 F. 4 F.
„ ornatum, *Goldf.*	*	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Ch, Dev. 3 F, Hun, IW. 4 F.
„ pseudo-ornatum, *Cott.*	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 F.
„ Rhodani, *Ag.*	*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Ch.
„ *Roissyi, Desor.* (*see* variolare).																
„ *tumidum, Wdw.* (*see* ornatum).																
„ variolare, *Brongn.*	*	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Ch, Dev. 3 Common. 4 F.
Pygurus lampas, *de la Beche*	*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Pyrina Desmoulinsi, *d'Arch.*	..	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev, Ch.
„ lævis, *Ag.* - -	*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ ovulum, *Lam.* - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev, Ch.
„ *Pratti Forbes* (*see* Desmoulinsi).																
Salenia Austeni, *Forbes* -	-	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 MB. 3 F, Be. 4 Nor.
„ cf. Austeni, *Forbes* -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 IW.
„ Clarki, *Forbes* - -	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2 Dev. 3 F. Sus. IW.
„ geometrica, *Ag.* -	-	-	-	-	-	-	-	-	-	-	-	-	12	13	-	12 Sal. 13 Nor, Sal, Ha.
„ gibba, *Ag.* - - -	*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.

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ECHINODERMATA—Cont.																
Echinoidea—Cont.																
Salenia granulosa, *Forbes*	-	-	2	3	-	-	6	7	8	9	10	-	12	13	-	2 Dev. 3 IW. 6 Do IW. 7 Do, Sus. Dev, He. 8 Dev. 9 SD, WK. Sus, IW. 10 Ha, WK. 12 Ha, IW, Sal. 13 Sal. ND.
„ petalifera, *Ag.*	*	1	2	3	-	-	-	-	-	-	-	-	-	-	-	1 MB. 2 Dor, Ch, Dev. 3 F, Sus, IW.
„ magnifica, *Wright*	-	-	-	-	-	-	-	-	-	-	-	-	12	13	-	12 Sal. 13 Nor.
„ minima, *Ag.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Ha, Sal.
„ sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
Stegaster (*see* Cardiaster).																
Trematopygus sp. nov.	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Asteroidea and Crinoidea.																
Antedon laticirra, *Carp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Wilts.
„ Lundgreni, *Carp.*	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 Mar.
„ paradoxa, *Goldf.*	*	-	-	-	-	-	-	-	-	-	?	-	-	-	-	? 10 Do.
„ perforata, *Carp.*	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 Mar.
„ striata, *Carp.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	? 10 Do.
„ rugosa, *Carp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Sussex.
Arthraster Dixoni, *Forbes*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MC. Sus.
Bourgueticrinus ellipticus, *Miller.*	-	-	-	-	-	-	-	-	-	9	10	11	12	13	-	9 to 12 common. 13 Sal, IW SD.
„ sp. nov.	-	-	-	-	-	-	-	-	-	-	10	11	-	-	-	10 Ha. 11 Ha, Sus.
Calliderma latum, *Forbes*	-	1	-	3	-	-	-	-	-	-	-	11	12	13	-	1 MB. 3 F, Sus. 10 WK. 11 Ha. 12 Ha. 13 SD.
„ mosaicum, *Forbes*	-	-	-	3	4	-	-	7	-	-	-	-	-	-	-	3 F, Sus. 4 F. 7 Do.
„ Smithiæ, *Forbes*	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	? 3 F. 4 Sus, Kent.
„ sp.	-	-	-	-	-	-	-	-	-	-	10	11	-	-	-	10 IW. 11 IW.
Glenotremites (*see* Antedon).																
Goniaster (*see* Calliderma, Metopaster, Nymphaster, Mitraster and Pentagonaster).																
Marsupites testudinarius, *Schloth.*	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 common.
Metopaster Bowerbanki, *Forbes.*	-	-	-	-	-	-	-	-	-	9	10	-	12	-	-	9 NW. 10 WK. 12 Sal.
„ cingulatus, *Sladen*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 WK.
„ cornutus, *Sladen*	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	6 Dev.
„ Mantelli, *Forbes*	-	-	-	-	-	-	-	-	-	9	10	-	-	13	-	9 Sal. 10 WK, Sal, NW. Nor. 13 Sal, Nor.
„ Parkinsoni, *Forbes*	-	-	-	-	-	-	-	7	-	-	10	11	12	13	-	7 Ha. 10 and 11 Common. 12 Sal, Ha. 13 IW, Sal, Nor.
„ *semilunatus Park.* (*see* Mantelli).																
„ *sublunatus, Forbes* (*see* uncatus).																
„ uncatus, *Forbes*	-	-	-	-	-	-	-	-	-	-	10	11	12	13	-	10 WK, Sal. 11 Sal. 12 Ha, Sal. 13 Sal.
„ zonatus, *Sladen*	-	-	-	-	-	-	-	-	-	-	10	-	12	-	-	10 Ha, WK. 12 Ha.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
ECHINODERMATA—Cont.																
Asteroidea and Crinoidea—Cont.																
Mitraster compactus, *Forbes*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MC. Sus.
" Hunteri, *Forbes* -	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 WK, Sal.
" rugatus, *Forbes* -	-	-	-	-	-	-	-	7	-	-	10	-	12	-	-	7 IW. 10 Sal, Ha. 12 Ha.
Nymphaster Coombei, *Forbes*	-	-	-	3	-	-	-	7	-	-	10	-	-	-	-	3 Sus. 7 Sus. 10 WK.
" marginatus, *Sladen.* -	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
" oligoplax, *Sladen.* -	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11 Sal. 12 Sal.
Ophiura serrata, *Roem.* -	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Ha.
" subcylindrica?, *Hag.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
Oreaster Boysi, *Forbes* - -	-	-	-	-	-	-	-	-	-	-	10	-	12	-	-	10 WK. 12 Sal.
" bulbiferus, *Forbes*	-	-	-	-	-	-	-	-	-	-	10	-	12	13	-	10 Ha. Ha, Sal. 12 Ha. Sal. 13 SD.
" coronatus, *Forbes* -	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4 Kent, Sus.
" obtusus, *Forbes* -	-	-	-	-	-	-	-	-	-	9	-	-	12	13	-	9 Sal. 12 Sal. 13 Sal, Sus.
" ocellatus, *Forbes* -	-	-	-	-	-	-	-	-	-	-	-	11	12	13	-	11 to 13 Sal.
" pistilliferus, *Forbes*	-	-	-	-	-	-	-	-	8	-	10	11	-	-	-	8 SD. 10 Ha. 11 Nor.
" squamatus, *Forbes* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Kent.
" sp. - - - - -	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Mid.
Pentacrinus Agassizi, *Hag.*	*	1	-	3	4	-	6	7	8	9	10	11	-	-	14	1 E, Cam. 4 Cam. 6 Dev. 7 IW. 8 and 9 common. 11 SD. 14 Tr.
" Bronni, *Hag.* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
" sp. - - -	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	13 Ha.
Pentagonaster lunatus, *Woodw.*	-	-	-	-	-	-	-	-	-	-	10	-	-	13	-	10 Ha. 13 Nor, Sal.
" megaloplax, *Sladen.*	-	-	-	-	-	-	-	-	-	9	10	11	-	-	-	9 WK. 10 Sal, WK. 11 Sal.
" sp. - -	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11, 12 Yo.
Pycnaster angustatus, *Forb.*	-	-	-	-	-	-	-	-	-	-	10	11	12	13	-	10 Ha. 11 Sal. 12 Ha, Sal. 13 Sal.
Stellaster Comptoni, *Forbes*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Loc. unknown.
" elegans, *Forbes*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 F.
Uintacrinus westfalicus, *Schlüt.*	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 Mar, Sus, Ha, Sal.
ACTINOZOA.																
Axogaster cretacea, *Lons.* -	-	-	-	-	4	-	6	-	8	9	10	11	12	13	14	4 WK. 6 Do. 8 SD. 9 WK. 10 to 12 common. 13 IW, SD. 14 Tr.
Bathycyathus Sowerbyi *E. & H.*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 IW. 2 Ch.
Caryophyllia cylindracea, *Reuss.*	-	-	-	-	-	-	-	-	8	9	10	11	12	13	-	From 8 to 11 common. 12 Yo. 13 SD, Nor.
" Lonsdalei, *Dunc.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
" Tennanti, *Dunc.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
Cœlosmilia cornucopiæ, *Dunc.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
" cylindrica, *Dunc.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
" granulata, *Dunc.*	-	-	-	-	-	-	-	-	-	-	-	-	12	13	-	12 Suf. 13 Nor.
" laxa, *E. & H.* -	-	-	-	-	-	-	-	-	-	-	-	11	12	13	-	11 Mar. SD. 12 Sal, Mar, SD. 13 Sal, SD, Nor.
" regularis, *Tomes*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
" Wiltshirei, *Dunc.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	1 Chloritic Marl (Stauronema)	2 Devon Cenomanian, &c.	3 Chalk Zone of Am. varians.	4 Zone of Hol. subglobosus.	5 Zone of Act. plenus.	6 Zone of Rhynch. Cuvieri.	7 Zone of Terebratulina.	8 Zone of Hol. planus.	9 Z. of Mic. cortestudinarium.	10 Zone of Mic. coranguinum.	11 Zone of Marsupites.	12 Zone of Act. quadratus.	13 Zone of Bel. Mucronata.	14 Zone of Ostrea lunata.	
ACTINOZOA—Cont.																
Cœlosmilia, Woodwardi, *Dunc*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Loc. unknown.
Diblasus grevensis, *Lonsd.* -	-	-	-	-	-	-	-	-	8	9	10	11	12	13	14	9 WK. 10 WK. 12 Sal. 13 Nor. 14 Tr.
„ new sp. - - -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
Epiphaxum auloporoides, *Lonsd.*	-	-	-	-	-	-	-	-	8	9	10	11	-	-	-	8 Do, Sus. 9 Do, Sus, WK. 10 Ha, EK, Sus. 11 Sus, Mar.
Micrabacia coronula, *Goldf.*	*	1	2	3	4	-	-	-	-	-	-	-	-	-	-	1 passim. 2 . 3 passim. 4 F.
„ sp. - - -	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	7 Ha.
Onchotrochus Carteri, *Dunc.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
„ serpentinus, *Dunc.*	-	-	-	3	4	-	-	-	-	9	10	-	12	13	14	3 IW, Nor. 4 Nor. 9 WK. 10 EK, WK. 12 Ha. 13 Sal. 14 Tr.
Parasmilia centralis, *Mant.*	-	-	-	-	-	-	6	7	8	9	10	11	12	13	-	6 Do, Dev. 7 Do, Dev. 8 to 13 common.
„ „ var. graveseana, *E. & H.*	-	-	-	-	-	-	-	-	-	-	10	11	12	-	-	10 EK. 11 Mar. 12 Sal.
„ „ var. Mantelli, *E. & H.*	-	-	-	-	-	-	-	-	-	-	10	-	12	13	-	10 EK. 12 Sal. 11 Sal.
„ cylindrica, *E. & H.*	-	-	-	-	-	-	-	-	-	-	10	-	-	13	-	10 EK. 13 Nor.
„ Fittoni, *E. & H.* -	-	-	-	-	-	-	-	-	-	-	-	11	12	13	-	11 Mar, Sus. 12 Sus. S.D. 13 Nor.
„ granulata, *Dunc.* -	-	-	-	-	-	-	-	-	-	-	10	11	12	-	-	10 EK. 11 Mar. 12 Sus.
„ monilis, *Dunc.* -	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 WK, Yo.
„ serpentina, *E. & H.*	-	-	-	-	-	-	-	-	-	-	10	11	-	-	-	10 Sal. 11 WK.
Smilotrochus elongatus (*see* Bathycyathus).																
Spinopora Dixoni, *Lonsd.* -	-	-	-	-	-	-	-	-	-	9	-	11	12	-	-	9 WK. 11 Sal. 12 Sal.
Stephanophyllia Bowerbanki, *E. & H.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	L.C., Dover.
„ Michelini, *Lonsd.*	-	-	-	-	-	-	-	-	-	-	10	11	-	13	-	10 EK. 11 Mar. 13 SD.
„ numismalis, *Tomes.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Sal.
Synhelia sharpeana, *E. & H.*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10 Sur. and Kent.
Trochosmilia sp. 1 - -	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 IW. 3 IW.
„ sp. 2 - -	-	-	-	-	-	-	-	-	-	-	-	-	-	13	14	13 IW. 14 Tr.
HYDROZOA.																
Parkeria sphærica, *Carter.*	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam. 2 WD.
„ sp.																
SPONGIDA.																
1. *Calcareous Sponges.*																
Elasmostoma consobrinum, *d'Orb.*	*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1 MB, IW. 2 Dev.
„ crassum, *Hinde*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Up. Chalk, Bromley.
„ scitulum, *Hinde*	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 Sus. 10 WK. Up. Chalk, Kent.
„ sp. - - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Pharetrospongia Strahani, *Sollas.*	-	1	-	-	-	-	-	7	8	9	10	11	12	13	-	1 Cam. 7 Do. 8 Do. Sus. 9 to 12 common. 13 SD.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
SPONGIDA—Cont.																
1. *Calcareous Sponges*—Cont.																
Tremacystia d'Orbignyi, *Hinde.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
„ siphonoides, *Mich.*	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2 Dev.
Porosphæra globularis, *Phil.*	–	1	–	–	–	–	6	7	8	9	10	11	12	13	14	1 MB. 6 Do, Sus. 7 Do, Ha, Sus. 8 Do. common from 9 to 13. 14 Tr.
„ pileolus, Lam. -	–	1	–	–	–	–	6	–	8	9	10	11	12	13	14	1 MB. 6 Do, Sus. 8 IW. common from 9 to 13. 14 Tr.
„ *urceolata, Phil.* (see pileolus)																
„ Woodwardi, *Carter.*	–	–	–	–	–	–	–	–	8	9	10	11	12	13	14	8 Do. common from 9 to 13. 14 Tr.
2. *Siliceous Sponges.*																
Acanthoraphis intertextus, *Hinde.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Up. Chalk, Kent.
Aphrocallistes sp. - -	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 MB.
Aulaxinia costata, *Hinde* -	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 WK.
Bolospongia constricta, *Hinde.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 Yo.
„ globata, *Hinde*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 Yo.
Brachiolites (*see* Craticularia).																
Callodictyon augustatum, *Hinde.*	–	–	–	–	–	–	–	–	–	–	–	11	–	–	–	11 Sus.
Callopegma ficoideum, *Hinde*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 WK.
„ obconicum, *Hinde*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Up. Chalk, S. Eng.
„ sp. - - -	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 IW.
Camerospongia aperta, *Hinde.*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Do.
„ campanulata, *T. Smith.*	–	–	–	–	–	–	–	7	8	–	–	–	–	–	–	7 Sus. 8 common.
„ capitata, *T. Smith*	–	–	–	–	–	–	6	7	8	–	–	11	12	–	–	6 Do. 7 Do. 8 Sus. 11 Yo. 12 Yo.
„ subrotunda, *Mant.*	–	–	–	–	–	–	6	–	8	–	10	–	12	–	–	6 Ha. 8 Do, Sus, NW. 10 Ha. Nor. 12 Ha.
Cephalites alternans, *T. Smith*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Up. Chalk, S. Eng.
„ Bennettiæ, *Mant.*	–	–	–	–	–	–	6	7	8	9	–	–	–	–	–	6 Do. 7 Do. 8 Do. 9 WK, Do, and Lewes, Sussex.
„ bullatus, *T. Smith*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Up. Chalk, S. Eng.
„ catenifer, *T. Smith*	–	–	–	–	–	–	–	–	8	–	–	11	–	–	–	8 Do, Sus. 11 Mar.
„ *compressus, Smith* (*see* catenifer).	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
„ *guttatus* (*see* longitudinalis).																
„ longitudinalis, *T. Smith.*	–	–	–	–	–	–	6	7	8	–	10	11	–	–	–	6 Do. 7 Do. 8 Do, Sus. 10 EK. 11 Mar.
„ paradoxus, *Smith*	–	–	–	–	–	–	–	7	8	–	10	–	–	–	–	7 Bd. 8 Bd. 10 Ha, NW.
„ *perforatus* (*see* Tremabolites).																
Chenendopora callodictya? Zitt.	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 MB.
Cincliderma quadratum, *Hinde.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Up. Chalk, S. Eng.
Cliona cretacea, *Portlock* -	–	–	–	–	–	–	–	7	8	9	10	11	12	13	–	7 Do, Sus. 8 Do, Sus 9 to 12 common. 13 SD. Nor.

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SPONGIDA—Cont.																
Siliceous Sponges—Cont.																
Cliona glomerata, *Morris*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
Cœloptychium agaricoides *Goldf.*	-	-	-	-	-	-	-	-	-	-	-	11	12	13	-	11 Yo. 12 Yo. 13 Nor.
„ **deciminum**, *Rœmer.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ **sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
Coscinopora infundibuliformis, *Goldf.*	-	-	-	-	-	-	-	-	8	9	10	11	12	13	-	8 Do, Ox. 9, 10, 11 common. 12 Sus, SD. Nor. 13 SD. Nor.
„ **quincuncialis**, *T. Smith.*	-	-	-	-	-	-	-	-	8	9	10	-	-	13	-	8 NW, Be, Es. 9 WK. 10 NW, Es. 13 Nor.
„ **sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
Craticularia Fittoni, *Mant.* (=**Brachiolites digitatus**, *Smith*, and **Dendrospongia fenestratus**).	-	1	-	3	-	-	6	7	8	9	-	-	-	-	-	1 E. 3 Sus, IW, SD. 6 Do, Sus. 7 Do, Sus, Dev. 8 Do, Sus. 9 Do.
Craticularia subseriata, *Rœmer.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ **sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
Dendrospongia (*see* **Craticularia**).																
Diplodictyon Bayfieldi, *Hinde.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
Doryderma ramosum, *Mant.*	-	-	-	-	-	-	6	7	8	9	10	11	12	13	-	6 Do. 7 Do. 8 Do, Sus. 9 and 10 Common. 11 Mar, Sus, Mid. 12 Sus, SD. 13 Nor.
„ **Rœmeri**, *Hinde*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 WK.
„ **sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
Etheridgea sp.	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Es.
Guettardia *angularis*, *Smith* (*see* **stellata**).																
„ **stellata**, *Mich.*	-	-	-	-	-	-	6	7	8	9	10	11	12	13	-	6 Do, Sus. 7 Do, Sus. Dev. 8 to 10 common. 11 Mar, Sus. 12 Sus, SD. 13 Nor.
Hallirhoa agariciformis, *Benett*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 IW.
„ **costata**, *Lam.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Dor.
Heterostinia obliqua, *Benett*	-	-	-	-	-	-	6	7	8	9	10	11	12	-	-	6 Do. 7 Do, Sus. 8 Do, Sus, SD. 9 and 10 common. 11 Do, Sus, SD. 12 Sus, SD, Yo.
Isoraphinia tecta, *Rœmer*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
Jerea cordiformis, *Hinde*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3 or 4 Do.
„ **excavata ?**, *Mich.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Up. Chalk, Wilts.
„ **Websteri**, *Sow.*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	7 IW.
„ **sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
Jereica clava, *Lee.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
Leptophragma fragilis, *Rœmer*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Up. Chalk, S. Eng.
„ **Murchisoni**, *Goldf.*	-	-	-	3	-	-	-	7	8	9	10	11	12	13	-	3 Sus, Hun. 7 Do. 8 Do. 9 Do, Sus. 10 EK, Sus. 11 Mar, Sus. 12 Sus. 13 SD.
Manon marginatum *Phil.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
Nelumbia tuberosa, *Hinde*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	Do. (Grey Ch.). Up. Chalk, S. Eng.
„ **sp.**	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
SPONGIDA—Cont																
Siliceous Sponges—Cont.																
Nematinion calycinum, ***Hinde***	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
„ sp. - - -	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2 Dev.
Ophiraphidites anastomosans, ***Hinde***	-	-	-	-	-	-	-	-	-	-	10	11	-	-	-	10 EK. 11 EK.
Ophrystoma micrommatum, ***Roemer***	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 IW. and Do. (Grey Ch.)
Pachastrella convoluta, ***Hinde***	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
Pachinion scriptum, ***Hinde***	-	-	-	-	-	-	6	7	8	9	10	11	12	-	-	6 Do. 7 Do. 8 Do. 9 Do. WK, Sus. 10 Do, Sus. 11 Do Sus. 12 Yo.
Pholidocladia dichotoma, ***Hinde***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Wilts.
„ **ramosa,** ***Hinde***	-	-	-	-	-	-	-	7	8	9	10	11	12	-	-	7 Do. 8 Do. 9 Do, WK, Sus. 10 Do, Sus. 11 Mar, Sus. 12 Sus.
Phymatella intumescens, ***Rœmer***	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Sus. Bk.
„ **reticulata,** ***Hinde***	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
Phymaplectia cribrata, ***Hinde***	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	9 Wilts.
„ **irregularis,** ***Hinde***	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	9 Wilts.
„ **scitula,** ***Hinde***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Wilts.
„ **spinosa,** ***Hinde***	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	Wilts
Placotrema cretaceum, ***Hinde***	-	-	-	-	-	-	-	-	8	9	10	11	-	-	-	8 Do, Ox, Bd. 9 Do. 10 EK. 11 Mar.17
Pleurostoma radiatum, ***Rœmer***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Sth Eng.
Plinthosella compacta, ***Hinde***	-	-	-	-	-	-	-	7	8	9	10	11	12	-	-	7 Do. 8 Do, Sus. 9 WK, Do, Sus. 10 EK, Sus. 11 Mar, Sus. 12 Sus. SD.
„ **convoluta,** ***Hinde***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Wilts.
„ **nodosa,** ***Hinde*** -	-	-	-	-	-	-	-	-	-	9	10	11	-	-	-	9 NW. 10 EK. 11 Mar. and UC. Wilts.
„ **squamosa,** ***Zitt.*** -	-	-	-	-	-	-	-	-	8	9	10	11	12	13	-	8 Do. 9 Do, WK, Sus. 10 EK, Sur, Sus. 11 Mar, Sus. 12 Sus. 13 Nor.
„ sp. - - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—
Plocoscyphia convoluta, ***T. Smith***	-	-	-	3	-	-	6	7	8	9	10	11	12	-	-	3 NW. 6 Do, Sus, Dev, 7 Do, Sus. 8 to 11 common. 12 Sus.
„ **elegans,** ***T. Smith***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Kent and Sus,
„ **fenestrata,** ***T. Smith***	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 MB. IW. 3 F, IW, and L. C., Wilts.
„ **flexuosa,** ***Mant.***	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Bd. and UC. Sth Eng.
„ **foliacea,** ***T. Smith***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Sth Eng.
„ **labrosa,** ***T. Smith***	-	1	-	3	-	-	6	7	8	9	10	11	-	-	-	1 F, E, IW. 3 common. 6 Do. Sus. 7 Do, Sus. 8 Do, Sus. 9 Do, Sus. 10 EK, Sus. 11 Mar.
„ ***mæandrina Goldf.*** (=labrosa).																
„ **labyrinthica,** ***Mant.***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Kent.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian. *	1 Chloritic Marl (Stauronema) 1	2 Devon Cen manian, &c. 2	3 Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
SPONGIDA.—Cont.																
2. *Siliceous Sponges.*—Cont.																
Plocoscyphia reticulata, *Hinde*	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Sus, IW. 3 IW.
„ subruta, *Quendst.*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 IW.
„ vagans, *Hinde*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Kent.
Polyblastidium racemosum, *T. Smith*	-	-	-	-	-	-	-	-	-	-	10	11	-	-	-	10 EK. 11 Mar.
„ tuberosum, *T. Smith*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Kent?
Polyjerea arbuscula, *Hinde*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3 or 4 Dover.
„ lobata, *Hinde*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3 or 4 Dover.
Porochonia simplex, *Smith*	-	-	-	-	-	-	-	-	8	-	10	11	12	-	-	8 Bd, Es. 10 EK, Sus. 11 Sus, Mar. 12 Sus.
Ragadinia clavata, *Hinde*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Wilts.
„ compressa, *Hinde*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Wilts.
„ sulcata, *Hinde*	-	-	-	-	-	-	-	7	-	9	-	-	-	-	-	7 Do, 9 Wilts.
Scyphia pedunculata, *Rœmer*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
Scytalia fastigiata, *Lee*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
„ radiciformis, *Phil.*	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11 Yo. 12 Yo.
„ terebrata, *Phil.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
Seliscothon explanatus, *Rœm.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
„ planus, *Phil.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
Sestrocladia furcatus, *Hinde*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3 or 4 Dover.
Siphonia ficus, *Goldf.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3 or 4 Dover.
„ Kœnigi, *Mant.*	-	-	-	-	-	-	-	7	8	9	10	11	12	13	-	7Do, Ha. 8 SD. Do. 9 SD Do. WK, Sus. 10 SD. Do. WK, Sus. 11 Mar. Sus. SD. 12 Sus. SD. 13 SD.
„ tulipa, *Zitt.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Sus, IW.
Sporadoscinia capax, *Hinde*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC, Sth Eng.
„ micrommata, *Rœm.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Kent.
Stachyspongia spica, *Rœm.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3 or 4 Do, UC. Sth Eng.
Stauractinella cretacea, *Hinde.*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor and UC. Sth Eng.
Stauronema Carteri, *Sollas*	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 F, E, IW, MB. 3 IW
„ lobatum, *Sollas*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 F
„ planum *Hinde*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 F.
Stelletta inclusa, *Hinde*	-	-	-	-	-	-	-	7	8	9	10	11	-	-	-	7 Do. 8 Do. 9 Do, WK. 10 Sus. 11 Mar.
Stichophyma tumidum, *Hinde*	-	-	-	-	-	-	-	7	8	9	10	11	12	-	-	7 Do. 8 Do. 9 WK, Do, Sus. 10 Do, Sus, SD. 11 Do, Sus. 12 Sus, Yo.
„ sp.	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 WK.
Strephinia convoluta, *Hinde*	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Sus. 3 Do, Hun.
„ reteformis, *Hinde*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3 or 4 Do.
Talpina dendrina, *Hag*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14 Tr.
„ ramosa, *Hag*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14 Tr.
„ solitaria, *Hag*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14 Tr.
Tethyopsis cretaceus, *Hinde*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
Thamnospongia clavellata, *Benett.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. Wilts & Kent.
„ glabra, *Hinde*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Wilts & Devon?

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
SPONGIDA—Cont.																
2. *Siliceous Sponges*—Cont.																
Thamnospongia reticulata? *Hinde*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3F.
" sp. - -	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	9 WK. 10 Mar, Mid.
Thecosiphonia nobilis, *Rœmer.*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Wilts.
" turbinata, *Hinde*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	9 Wilts.
Toulminia obliqua, *Hinde* -	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 Mar, UC. S Eng.
Tremabolites perforatus, *T. Smith*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Bd & UC. S Eng.
Trachysycon sulcatum, *Hinde*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC. S Eng.
Turonia variabilis, *Mich.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
Ventriculites alcyonoides, *Mant.*	-	-	-	-	-	-	-	7	8	9	10	-	-	-	-	7 Ha. 8 common. 9 Sur. 10 WK.
" alternans (? = infundibuliformis).	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
" angustatus, *Rœmer.*	-	-	-	-	-	-	-	-	8	9	-	-	-	-	-	8 Bd. 9 WK.
" convolutus, *Hinde*	-	-	-	-	-	-	-	-	-	-	10	11	12	-	-	10 EK, Sus, SD. 11 Sus, Mar. 12 Sus.
" cribrosus, *Phil.*	-	-	-	-	-	-	6	7	8	9	10	11	12	13	-	6 Do. 7 Do, Sus. 8 to 11 common. 12 Sus, Yo. 13 SD, Nor.
" decurrens, *T. Smith.*	-	-	-	-	-	-	6	7	8	9	10	11	12	13	-	6 Do. 7 Do, Sus, Dev. 8 to 10 common. 11 Sus, SD, Mar. 12 Sus. SD. 13 Nor.
" impressus. *T. Smith.*	-	-	-	-	-	-	6	7	8	9	10	11	12	13	-	6 Do. 7 Do, Sus, Cam. 8 to 10 common. 11 Sus, SD, Mar. 12. Sus. SD. 13 Nor. 8.
" infundibuliformis, *S. Wdw.*	-	-	-	-	-	-	-	7	8	9	10	11	12	-	-	7 Do, Sus, Ha. 8 Do, Sus. 9 Do, Sus, WK. 10, 11, EK, Sus. 12 Sus, Yo.
" mammillaris, *T. Smith.*	-	-	-	-	-	-	6	7	8	9	10	11	12	-	-	6 Do. 7 Do, Cam. 8 common. 9 Do, Sus, BK. 10 EK. 11 Mar, Sus. 12 Sus.
" moniliferus *Roem.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 IW.
radiatus, *Mant.*	-	-	-	-	-	-	6	7	8	9	10	11	12	13	-	6 Do. 7 to 11 common. 12 Sus, SD, Yo. 13 SD, Nor.
" *quincuncialis* (*see* Coscinopora).																
" *simplex* (*see* Porochonia).																
Verrucocœlia tubulata, *T. Smith.*	-	-	-	-	-	-	-	-	8	-	10	11	-	-	-	8 Bd. 10 EK. 11 Mar.
" vectensis, *Hinde.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8 IW
" sp. - -	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11 Ha.
Verruculina astrea, *Hinde* -	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
" miliaris, *Reuss*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
" papillata, *Hinde.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	12 Yo.
" plicata, *Hinde* -	-	-	-	-	-	-	-	-	-	-	-	11	12	-	-	11 Yo. 12 Yo.

SPECIES.	* Found in Selbornian.	Lower Chalk. 1 Chloritic Marl (Stauronema)	2 Devon Cenomanian, &c.	3 Chalk Zone of Am. varians.	4 Zone of Hol. subglobosus.	5 Zone of Act. plenus.	Mid'le Chalk. 6 Zone of Rhynch. Cuvieri.	7 Zone of Terebratulina.	Upper Chalk. 8 Zone of Hol. planus.	9 Z. of Mic. cortestudinarium.	10 Zone of Mic. coranguinum.	11 Zone of Marsupites.	12 Zone of Act. quadratus.	13 Zone of Bel. mucronata.	14 Zone of Ostrea lunata.	LOCALITIES AND REMARKS
SPONGIDA—Cont.																
2. *Siliceous Sponges*—Cont.																
Verruculina pustulosa, *Hinde.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 Yo.
„ Reussi, *McCoy*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 Yo.
„ sp. - - -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 Ha.
FORAMINIFERA.																
Ammodiscus charoides, *P. and J.*	–	–	–	3	4	5	6	7	8	–	–	–	–	–	–	3 Yo. 4 Nor, Lin, Yo. 5 Do, He 6 Dor, He, Nor, Yo. 7 Dor. 8 Nor.
„ centrifuga, *Brady.*	–	–	–	–	–	–	–	–	–	–	–	11	–	–	–	11 Yo.
„ gordialis, *P. and J.*	*	–	–	3	4	5	6	7	–	–	–	–	–	–	–	3 Yo 4 Nor, Lin, Yo, He. 6 Yo. 7 Yo.
„ incertus, *d'Orb.*	*	–	–	3	4	5	6	7	8	9	10	11	12	–	–	3 Y. 4 and 5 common. 6, 7 passim. 8 Nor. Yo. 9 He, Do. 10 Dor. 11 Yo. 12 IW.
„ tenula, *Brady.*	*	1	–	–	4	5	6	7	–	–	–	–	12	–	–	1 Cam. 4 Nor, Lin. 5He. 6 Nor. 7 Nor. 12 Yo.
„ sp. nov. - -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Yo.
Anomalina ammonoides, *Reuss.*	*	1	–	3	4	5	6	7	8	9	10	11	12	13	14	Passim.
„ ariminensis, *d'Orb.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ clementiana, *d'Orb.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
„ complanata, *Reuss.*	*	1	–	3	–	5	–	–	–	–	–	–	–	13	–	1 Nor, IW. 3 Cam. 4 BD. 5 Do, He. 13 Wilts.
„ grosserugosa, *Gümbel.*	*	1	–	–	–	–	–	–	–	–	–	–	12	–	–	1 Cam. 12 Bk
„ rotula, *d'Orb.* -	–	–	–	–	–	–	–	–	8	–	–	–	12	–	–	8 Yo. 12 Bk.
„ rudis, *Reuss* -	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ new variety -	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	He.
Bolivina decorata, *Jones.* -	–	–	–	–	–	–	–	–	–	–	–	–	12	13	–	12 W. 13 Nor.
„ dilatata, *Reuss* -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ nobilis, *Hantken* -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ obsoleta, *Eley.* -	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	Wilts.
„ punctata, *d'Orb.* -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ strigillata, *Chap.* -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ textilarioides, *Reuss.*	*	–	–	3	1	–	–	7	–	–	–	–	12	–	–	3 Cam. 4 Hun. 7 Dor. 12 Bk.
„ sp. nov. (nr decorata)	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 Dor.
„ sp. nov (nr punctata.)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
Bulimina affinis, *d'Orb.* -	*	1	–	3	4	5	6	7	8	9	10	11	12	13	–	Passim.
„ brevis, *d'Orb.* -	*	1	–	3	4	5	6	7	8	9	10	11	12	13	–	Passim.
„ elegans, *Brady* -	*	1	–	3	–	–	–	–	–	–	–	–	12	–	14	1 Cam. 3 Dor, B.I 12 Bk. 14 Tr
„ „ var exilis, *Brady* -	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
„ elongata, *d'Orb.* -	–	–	–	–	–	–	–	7	–	–	–	–	–	–	–	He.
„ murchisoniana, *d'Orb.*	*	1	–	3	4	5	–	7	8	9	10	11	12	13	–	Common.
„ „ new var.	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	Wilts.
„ obtusa, *d'Orb.* -	*	1	–	3	4	5	–	–	8	9	10	11	12	13	–	Common.
„ obliqua, *d'Orb.* -	*	1	–	3	–	–	–	–	–	–	–	–	12	–	–	1 Cam, Nor. 3 F. Hun. 12. Bk

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	* Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
FORAMINIFERA—Cont.																
Bulimina Orbignyi, *Reuss* -	*	1	–	3	4	–	–	7	–	–	10	–	–	13	–	1 F, Dor, Cam. 3 Bd, Cam. 4 Dor, Do, He. 7 Do. 10 He. 13 Nor,
„ orbigniana, *Reuss*-	–	–	–	–	–	–	–	–	–	–	–	–	12	13	–	12 W. 13 Dor.
„ ovata, *d'Orb.*- -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ ovulum, *Reuss* -	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	Yo.
„ polystropha, *Reuss.*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	Sus.
„ Presli, *Reuss* -	*	1	–	3	4	–	6	7	–	–	10	11	12	–	14	1, 3, 4 passim. 6 Dor. 7 He. 10 WK, He. 11 Sus. 12 W. 14 Tr.
„ „ var. sabulosa, *Chap.*	*	1	–	3	4	–	–	–	–	–	–	–	–	–	–	1 Cam, Dor. 3 IW, Bd, Yo. 4 Dor.
„ pupoides, *d'Orb.* -	–	–	–	–	–	–	–	–	8	–	10	–	–	–	14	8 Sus. 10 Do, He. 14, Tr.
„ pyrula, *d'Orb.* -	*	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Bd, Cam, Hun.
„ rimosa, *Marsson* -	–	–	–	–	–	–	–	–	–	9	–	–	–	–	14	9 Dor. 14 Tr.
„ subsphærica, *Reuss*	–	–	–	–	–	–	–	–	–	–	10	–	12	–	–	10 He. 12 Bk.
„ trigona, *Chapm.* -	–	–	–	3	4	–	–	–	–	–	–	–	12	–	–	3 Yo. 4 He. 12 Bk.
„ variabilis, *d'Orb.* -	–	–	–	–	4	–	–	–	8	–	10	11	12	13	–	4 Dor, Do. 8 Ox. 10 Kent, He, Nor. 1 Dor, Sus. 12 Bk, W. 13 Dor.
„ sp. nov.- - -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Wilts.
Cristellaria acutauricularis, *F. & M.*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	Sus.
„ Bronni, *Rœmer* -	*	1	–	–	4	–	–	7	–	–	–	–	–	13	–	1 Cam. 4 Dor. 7 Do. 13 Nor.
„ convergens, *Born.*	*	1	–	3	4	–	–	7	–	9	10	–	12	13	–	1 Cam. 3 Bd, Cam. 4 Dor. 7 Do. 9 He. 10 common. 12 Bk, W. 13 Dor, Nor.
„ circumcidanea, *Berth.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ complanata, *Reuss*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ crepidula, *F. & M.*	*	1	–	–	–	–	–	–	8	–	10	–	–	–	–	1 Cam. 8 He. 10 WK.
„ cultrata, *Montf.* -	*	1	–	3	4	5	6	7	8	9	10	–	12	13	–	1 Cam. 3 F, Bd. 4 He, Hun. 5 Do. 6 Dev, He. 7 He, Dor. 8 & 9 common. 10 He. 12 Bk. 13 W, Nor.
„ cymboides, *d'Orb.*	*	1	–	–	4	–	–	–	–	–	–	–	–	13	–	1 Cam. 4 Dor. 13 Nor
„ diademata, *Berth.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
„ exilis, *Reuss* - -	*	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 Dor.
„ gaultina, *Berth.* -	*	1	–	3	4	5	–	7	8	–	10	11	–	–	14	Generally common.
„ gaudryana, *d'Orb.*	–	–	–	–	–	–	–	–	–	–	–	–	12	13	–	12 Bk. 13 W.
„ gemmata, *Brady*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 Bk.
„ gibba, *d'Orb.*- -	*	1	–	3	4	5	–	–	8	–	10	–	12	–	14	1 Cam, Nor. 3 F, Bd, Cam. 4 Som. 5 He. 8 Sus, He. 10 Kent, He. 12 W. 14 Tr.
„ gladius, *Philippi* -	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ Italica, *Defr.* -	*	–	–	3	4	–	–	–	–	–	–	–	–	–	–	3 Bed. 4 Som, Nor.
„ linearis, *Reuss* -	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ macrodiscus *Reuss.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam. Nor.
navicula, *d'Orb.* -	*	–	–	–	–	–	–	–	8	9	–	–	12	13	–	8 Sus. 9 Do. 12 Bk. 13 Nor.
„ oligostegia, *Reuss*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ parallela, *Reuss* -	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ planiuscula, *Reuss*	*	–	–	3	4	–	–	–	–	–	10	–	–	–	14	3 F, Bd. 4 Bd. 10 He, Nor. 14 Tr
„ recta ? *d'Orb.* -	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Bd.

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FORAMINIFERA.—Cont.																
Cristellaria rotulata, *Lam.* -	*	1	-	3	4	-	-	7	8	9	10	11	12	13	14	1 Cam, Dor, IW. 3 F. 4 He. 7 Do. Common from 8 to 12. 13 Dor, W. 14 Nor.
„ „ var macrodiscus. *Reuss*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ secans, *Reuss* -	*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	Bd.
„ „ var. angulosa, *Chap.*	*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	F.
„ sulcifera, *Reuss*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ scitula, *Berth.* -	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ sternalis, *Berth.*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ subulata, *Reuss* -	*	-	-	-	-	5	-	-	-	-	-	-	-	-	-	5 Som.
„ triangularis, *d'Orb.*	*	1	-	-	-	-	-	-	-	9	10	-	12	-	-	1 Cam. 9 Do. 10 Kent. 12 Bk, W.
„ tricarinella, *Reuss*	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	Yo.
„ trunculata, *Berth.*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ turgidula, *Reuss*	*	1	-	-	-	5	-	-	-	-	-	-	-	-	-	1 Cam. 5 Som.
„ sp. nov. (1) -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	F.
„ sp. nov. (2) -	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	He.
Discorbina Bertheloti, *d'Orb.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	Sus.
„ globularis, *d'Orb.*	*	-	-	3	-	-	-	-	-	-	-	-	-	-	14	3 Bd. 14 Tr.
„ rosacea, *d'Orb.* -	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	He.
Flabellina baudouiniana - *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ cordata, *Reuss* -	-	1	-	-	-	-	-	7	8	9	10	11	12	-	-	1 Cam. 7 Do. 8 Do, Sus. 9 Ct, Do, Sus. 10 EK, Sus. 11 Mar, Sus. 12 Sus.
„ didyma, *Reuss* -	*	1	-	-	-	5	-	-	-	-	-	-	-	-	-	1 Cam. 5 Do.
„ oblonga ?, *Münst.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8 Bd.
„ ornata, *Reuss* -	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ rugosa, *d'Orb.* -	-	-	-	3	-	-	-	-	-	-	-	11	12	13	-	3 Bd. 11 Dor. 12 Bk. 13 Nor.
Frondicularia affinis, *Marsson*	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	13 Nor.
„ angulosa, *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ angusta, *Nilss.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ archiaciana, *d'Orb.*	*	1	-	-	4	-	-	-	8	-	-	-	12	13	-	1 Cam. 4 Dor, Do. 8 Do, Bd, He. 12 Bk. 13 Nor.
„ angustissima, *Reuss*	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	—
„ Fritschi, *Perner*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
„ Goldfussi, *Reuss*	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	Bd.
„ guestphalica, *Reuss*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ inversa, *Reuss* -	*	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 F, Bd.
„ lanceola, *Reuss*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ Parkeri, *Reuss* -	*	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 Bd, F. 4 Dor.
„ striga, *Chapm.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ solea, *Marss.* -	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	He.
„ ungeri, *Reuss* -	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ verneuiliana. *d'Orb.*	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	He.
„ sp. - - -	-	-	-	-	-	5	-	-	-	9	-	-	-	-	-	5 Do. 9 WK.
Gaudryina baccata, *Schw.* -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.

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Gaudryina crassa, ***Marsson***	-	-	-	-	-	-	-	-	8		10	11	-	13	-	8 He. 9 He. 10 Dor. 11 Sus. 13 Nor.
„ dispansa, ***Chap.***	*	1	-	3	4	-	-	-	-	-	-	-	-	-	-	1 Cam, IW. 3 F, Bd, Yo. 4 Yo.
„ filiformis, ***Berth.***	*	1	-	3	4	5	6	7	8	-	-	-	-	-	-	1 Cam, Dor. 3 common. 4 Do, Hun. 5 He. 6 Dor. 7 Dor, Hun. 1 Nor.
„ „ new var.	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	He.
„ jonesiana, ***Wright.***	-	-	-	-	-	-	-	-	8	-	-	-	12	-	-	8 Sus. 12 Bk.
„ oxycona, ***Reuss*** -	*	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 F, Bd, Cam.
„ pupoides, ***d'Orb.***	*	1	-	3	4	5	-	-	8	9	10	-	-	13	-	common in 1, 3, 4, 5. 8 Sus. 9 Ch, Dor. 10 Dor, Kent, Nor. 13 Nor.
„ rugosa, ***d Orb.*** -	*	1	-	3	4	-	-	7	8	9	10	11	12	13	-	1 Cam. 3 Dor, Bd. Cam. 4 Do, Yo. 7 Do. 8 Sus, He. 9 He. 10 Dor, Do. 11 Mar. 12 Bk. 13 Nor.
„ sp. nov. 1, (depauperate form.)	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	3 Yo. 4 Yo.
„ sp. nov. 2 - -	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3 Yo.
Globigerina æquilateralis, ***d'Orb.***	*	1	-	-	-	-	-	7	8	-	-	-	12	-	-	1 Cam. 7 Do. 8 Sus. 12 Bk.
„ bulloides ***Brady.***	*	1	-	-	4	-	-	-	8	-	10	-	12	-	14	1 Cam. 3 F. 8 Sus. Do. 10 Do. He. Nor. 12 Bk. 14 Tr.
„ cretacea, ***d'Orb.***		1	-	3	4	5	-	7	8	9	10	-	12	-	-	Common in 1, 3, 4. 5 Som. 7 He, Do. 8 common. 9 and 10 generally distributed, but not common. 12 common.
„ linnæana, ***d'Orb.***	*	-	-	-	4	-	-	-	8	-	10	11	-	-	-	4 Dor. 8 Yo. 10 WK. 11 Sus.
„ marginata, ***Reuss***	-	1	-	3	4	5	6	7	8	9	10	11	12	13	-	Common in 1, 3, 4. 5 Som. 6 Dev. 7 He, Do. 8 common. 9 Do, He, Yo. 10 He, Nor. 11 Sus, Mar. 12 Bk. 13 common.
Gypsina cretæ, ***Marsson*** -	*	-	-	-	-	-	-	-	8	-	-	-	-	-	-	Sus.
Haplostiche sherborniana, ***Chap.***	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
Haplophragmium acutidorsatum, ***Hantk.***	*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	Yo.
„ agglutinans, ***d'Orb.***	*	1	-	3	4	-	-	-	-	9	-	-	-	-	-	1 Cam. 3 IW. 4 Nor. 9 Do.
„ ? emaciatum, ***Brady***	*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	F.
„ glomeratum, ***Brady***	*	1	-	3	4	-	-	-	-	-	-	11	-	-	-	1 Nor. 3 Dor, Bd, Yo. 4 Yo. 11 Yo.
„ globigeriniforme, ***P. & J.***	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
„ irregulare, ***Ræmer***	*	1	-	3	-	-	-	-	8	9	10	-	-	-	-	1 Cam, MB. 3 F. 8 Sus. 9 Ch 10 He.
„ microspirale, ***Chap.***	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ pseudospirale, ***Will.***	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.

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Haplophragmium nanum, *Brady*.	*	–	–	3	4	–	–	–	–	–	–	–	–	–	–	3 F. 4 Hun, Yo.
„ nonioninoides, *Reuss*.	*	1	–	3	4?	–	–	–	–	–	–	–	–	–	–	1 MB. 3 F, Cam, Yo. 4 ? Do.
„ ovatum, *Hag*.	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	Sus.
„ sp. nov. 1 -	–	–	–	3	–	–	–	–	–	–	–	11	–	–	–	3 F.
„ sp. nov. 2 -	–	–	–	–	4	–	–	–	–	–	–	–	–	13	–	4 Yo.
„ sp. nov. 3 -	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	5 Do.
Lagena acuticosta, *Reuss* -	*	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Wilts.
„ apiculata, *Reuss* -	*	1	–	3	4	–	–	–	–	–	–	–	–	–	–	1 Cam. 3 F, Bd. 4 Do.
„ gracillima, *Seguenza*.	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ globosa, *Montf*. -	*	–	–	–	–	–	–	–	–	–	–	–	12	–	14	12 Bk, Nor.
„ hispida, *Reuss* - -	*	–	–	–	4	–	–	–	–	–	–	–	–	–	–	Do.
„ lævis, *Montague* -	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ marginata, *W. and Boys*.	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
„ sulcata, *W. and Jac*.	*	–	–	3	–	–	–	–	–	–	–	–	12	–	–	3 Bd. 12 Bk.
„ striatopunctata, *Par. and Jon*.	*	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ striata, *W. and Boys*	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	He.
Lingulina carinata, *d'Orb*. -	–	–	–	–	–	–	–	–	–	–	10	–	–	–	–	? 10 Bk.
Lituola ovata, *Marsson* -	–	–	–	–	–	–	–	–	–	–	–	–	–	13	14	13 Nov. 14 Tr.
„ nautiloides, *Def*. -	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	—
„ placentula, *Chap*. -	–	1	–	–	4	–	–	–	–	–	–	–	–	–	–	1 Cam. 4 Y.
Marginulina æquivoca, *Reuss*.	*	1	–	–	–	–	–	–	8	–	–	–	–	–	–	1 Cam. 8 Sus.
„ debilis, *Berth*. -	*	–	–	–	–	–	–	–	–	–	–	11	–	–	–	Sus.
„ elongata, *d'Orb*.	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ glabra, *d'Orb*. -	*	1	–	3	–	–	–	–	–	–	–	–	12	–	14	1 Cam, IW. 3 F, Bd 12 Bk. 14 Nor.
„ hamulus, *Chap*.	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ inæqualis, *Reuss*	*	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 F.
„ Jonesi, *Reuss* -	*	1	–	3	–	–	–	–	–	–	–	–	–	–	–	1 Cam. 3 F, Bd.
„ linearis, *Reuss*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ Munieri, *Berth*.	*	–	–	3	–	–	–	–	–	–	–	–	–	–	–	Bd.
„ robusta, *Reuss*	*	–	–	3	4	–	–	–	–	–	–	–	–	–	–	3 F. 4 Nor.
„ soluta, *Reuss* -	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ striaticostata, *Reuss*	*	1	–	3	4	–	–	–	–	–	–	–	–	–	–	1 Cam. 3 F. 4 Dor.
„ trilobata, *d'Orb*.	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	Nor.
Miliolina agglutinans, *d'Orb*.	*	–	–	–	–	–	–	–	–	9	–	–	–	–	–	Yo.
„ Ferussaci, *d'Orb*. -	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ oblonga, *Montf*. -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ seminulum, *Linn*.	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	Sus.
„ tricarinata, *d'Orb*.	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ trigonula, *Lam*. -	–	–	–	–		–	–	–	–	–	–	–	12	–	–	Bk.
„ venusta, *Karrer*. -	*	1	–	3	–	–	–	–	–	–	–	–	12	–	–	1 Cam. 3 Bd, Cam
„ sp. nov. (near alveoliniformis, *Brady*)	–	–	–	3	4	–	–	–	–	–	–	–	–	–	–	3 Bd. 4 He.
„ sp. nov. (between alveoliniformis and agglutinans	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	Dor.
Nodosaria aculeata, *d'Orb*. -	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ (D.) communis, *d'Orb*.	*	1	–	3	–	5	–	–	8	–	–	–	12	–	–	1 Cam. 3 F, Bd, Cam. 5 Do. 8 Sus He. 13 Bk.
„ consobrina, *d'Orb*.	*	1	–	3	4	5	–	–	8	–	10	11	12	13	14	1 Cam. 3 Bd. 4 Dor 5 Do. 8 Sus. 10 He. 11 Dor. 12 Bk. 13 Nor. 14 Tr.
„ cylindracea, *Reuss*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ expansa, *Reuss* -	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
FORAMINIFERA—Cont.																
Nodosaria farcimen, *Reuss* (after Soldani).	*	1	–	3	4	–	–	–	–	–	10	11	–	13	14	1 Cam. 3 F, Bd, Cam. 4 Do. 10 He. 11 Kent. 13 W. 14 Tr.
" filiformis, *d'Orb.*	*	–	–	–	–	–	–	–	–	–	–	11	–	–	–	Dor.
" Fontannesi, *Berth.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
" gracilis, *d'Orb.*	*	1	–	–	–	–	–	–	8	–	–	–	–	–	–	Cam. 8 Bd.
" hispida, *d'Orb.*	*	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
" humilis, *Rœmer*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam. Nor.
" legumen, *Reuss*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam
" lorneiana, *d'Orb.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
" mutabilis, *Reuss*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
" mucronata, *Neug.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
" multicosta, *Neug.*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Bd.
" (D.) nodosa, *d'Orb.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
" obscura, *Reuss*	*	1	–	3	–	–	–	–	–	–	–	–	12	–	–	1 Cam. 3 F, Bd. 12 Bk.
" obliqua, *Linn.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
" oligostegia, *Reuss*	*	–	–	?3	4	–	–	–	–	9	–	–	–	–	–	3 Nor. 4 Do, Nor. 9 Ct.
" orthopleura *Reuss*	*	1	–	3	–	–	–	–	–	–	–	–	–	–	–	1 Cam, Nor. 3 F.
" pauperata, *d'Orb.*	*	1	–	–	–	–	–	–	–	–	–	–	12	–	14	1 Cam. 12 Bk. 14 Tr.
" paupercula, *Reuss*	*	1	–	3	–	–	–	–	?	–	–	–	–	–	–	1 Cam. 3 Bd.
" perpusilla, *Chap.*	*	1	–	3	–	–	–	–	–	–	–	–	–	13	–	1 Cam. 3 F, Bd. 13 Nor.
" plebeia, *Reuss.*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Cam.
" prismatica, *Reuss*	*	1	–	3	4	–	–	–	–	–	–	–	–	–	–	1 Cam. 3 F, Bd. 4 Dor.
" polytrema ? *d'Orb.*	–	–	–	–	–	–	–	–	–	–	–	11	–	–	–	Dor.
" radicula, *Linn.*	*	–	–	–	–	–	–	–	–	–	–	–	12	13	–	12 Bk. 13 W, Nor.
" raristriata, *Chap.*	*	1	–	3	–	–	–	–	–	–	–	–	–	–	–	1 Cam. 3 Bd.
" raphanus, *Linn.*	*	1	–	–	–	–	–	–	–	–	–	–	–	13	–	? 1 Cam. 13 W.
" raphanistrum, *Linn.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
" (D.) Rœmeri, *Neug.*	*	1	–	–	–	–	–	–	–	–	–	–	12	–	–	1 Cam. 12 Bk.
" soluta, *Reuss*	*	1	–	3	–	–	–	–	–	–	–	–	–	–	–	1 Cam. 3 F.
" tubifera, *Reuss*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
" tennicosta, *Reuss*	*	1	–	3	–	–	–	–	–	–	–	–	12	–	–	1 Cam. 3 Cam.
" Zippei, *Reuss*	*	1	–	–	–	–	–	7	8	9	10	11	12	13	14	1 Cam. 8 Bd, Do, Sus.? 9 Do, Ct, Sus. 10 EK, Sus. 11 Mar, Sus. 12 Sus. 13 Nor. 14 Tr.
Nubecularia jonesiana, *Chap.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
" novorossica, *Kar & Lin.*	–	–	–	–	–	–	–		–	–	–	–	12	–	–	Bk.
" tibia, *J. and P.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
" sp. nov. no. 1	–	–	–	3	4	–	–	–	–	–	–	–	–	–	–	3 IW. 4 Dor.
" sp. nov. no. 2	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	Yo.
Placopsilina cenomana, *d'Orb.*	*	1	–	–	4	–	–	–	–	–	–	–	–	–	–	1 Cam. 4 Dor.
" vesicularis, *Brady.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
" sp.	–	–	–	–	–	–	6	7	8	9	10	11	12	–	–	8 Do, Sus. 9. Ch, Do, Sus. 10 EK, Sus. 11 Sus, Mar. 12 Sur.
Planorbulina clementina, *d'Orb.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
" lorneiana, *d'Orb.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
Pleurostomella alternans, *Schweitz.*	*	1	–	3	4	5	–	–	8	–	–	11	–	13	–	1 Cam, Dor, Nor. 3 F. Bd. 4 Hun. 8 He, 11 Kent. 13 Nor.
" obtusa, *Berth.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian.	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
FORAMINIFERA—Cont.																
Pleurostomella subnodosa, *Reuss*	*		-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ sp. nov.	-		-	3	4	-	-	-	-	-	-	-	-	-	-	3 Yo. 4 Yo.
Polymorphina acuminata, *d'Orb.*	-		-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ communis, *d'Orb*	*		-	3	-	-	-	-	-	-	-	-	-	-	14	1 Cam. 3 F. 14 Tr.
„ fusiformis, *Rœmer.*	*		-	3	4	5	-	-	8	-	-	-	-	-	-	1 Cam. 3 F, Bd, Cam. 4 Dor. 5 Do. 8 Sus. He.
„ „ var. horrida, *Reuss.*	*		-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ „ var. acuplacenta, *J. & Chap.*	*		-	3	-	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 Bd.
„ gibba, *d'Orb.*	*		-	3	-	-	-	-	-	-	-	-	12	-	14	3 Bd. 12 Bk. 14 Tr.
„ „ var. acuplacenta, *J & Chap.*	*		-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ gutta, *d'Orb.* var. diffusa, *J. & Ch.*	*		-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ lactea, *W. and J.*	*		-	3	-	-	-	-	-	-	-	-	-	13	-	3 F, Bd. 13 Nor.
„ „ var. acuplacenta, *J. & Ch.*	*		-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ rotundata, *Born.*	*		-	-	-	-	-	-	-	-	10	-	-	-	-	Dor.
„ sororia, *Reuss*	*		-	3	-	-	-	-	-	-	-	-	12	-	-	3 F. 12 Bk.
„ „ var. cuspidata, *Brady*	*		-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
Pullenia sphæroides, *d'Orb.*	-		-	-	-	-	-	-	-	-	-	-	-	-	14	14 Tr.
„ quinqueloba, *Reuss.*	-		-	-	-	-	-	-	-	-	-	-	-	13	14	13 Nor. 14 Tr.
Pulvinulina elegans, *d'Orb.*	*		-	-	-	-	-	-	8	-	-	-	12	-	14	8 Sus. 12 Bk. 14 Tr.
„ Haidingeri, *d'Orb.*	-		-	-	-	-	-	-	-	-	-	11	12	13	-	11 Dor. 12 Nor. Bk. 13 Nor, Dor.
„ Karsteni, *Reuss*	-		-	-	4	-	-	-	-	-	-	-	12	-	-	4 Dor. 12 Bk.
„ micheliniana, *d'Orb.*	-		-	-	-	-	-	-	8	9	10	11	12	13	-	8 Do, He, Yo Common in 9, 10, 11, 12 and 13.
„ punctulata, *d'Orb.*	-		-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ repanda, *Fichet and Mol.*	-		-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ „ var. concamerata, *Mont.*	-		-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
Ramulina aculeata, *d'Orb.*	*		-	3	4	-	-	-	8	9	10	11	12	13	14	1 Cam. 3 F, Bd, Cam 4 Do, He. 8 Sus, Bd. 9 Ct, Do. 10 common. 11 Sus, Mar. 12 Sus. 13 Nor. 14 Tr.
„ globulifera, *Brady*	*		-	3	4	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 F. 4 Hun.
„ lævis, *Jones*	*		-	-	-	-	-	-	8	-	-	-	-	-	-	Sus.
Reophax cylindrica, *Chap.*	*		-	3	-	-	-	-	-	-	-	-	-	-	-	IW.
„ fusiformis, *Will.*	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 IW.
„ folkstoniensis, *Chap.*	*		-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ nodulosa, *Brady*	-		-	3	4	-	-	-	-	-	-	-	-	-	-	3 Yo. 4 Yo.
„ scorpiurus, *Montf.*	*	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 Dor.
„ sp. nov. 1	-		-	3	4	-	-	-	-	-	10	-	-	-	-	3 F, Dor, Nor. 4 Yo.
„ sp. nov. 2	-		-	-	-	-	6	-	-	-	-	-	-	-	-	—
„ sp. nov. 3	-		-	-	-	-	-	-	-	-	-	-	-	13	-	—

SPECIES		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	* Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. mucronata. 13	Zone of Ostrea lunata. 14	
FORAMINIFERA—Cont.																
Rhabdogonium tricarinatum, *d'Orb.* -	*	-	-	3	4	-	-	-	-	-	10	11	-	-	-	3 Bd, Cam 4 Do, Dor. 10 He. 11 Sus.
„ „ var. acutangulum, *Reuss.*	-	-	-	3	-	-	-	-	8	-	-	-	-	-	-	3 Cam. 8 Sus.
„ excavatum, *Reuss.*	*	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 F, Bd, Cam.
„ „ var. exilis, *Chap.*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
Rhizammina algæformis *Brady.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	Yo.
„ indivisa, *Brady.*	*	-	-	3	4	5	6	7	-	-	10	11	12	-	-	Fragments referable to this species are commonly present.
„ sp. nov. -	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	He, Yo.
Rotalia Beccari, *Linn.* -	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ Bosqueti? *Reuss* -	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	He.
„ Soldani, *d'Orb.* -	-	1	-	3	4	-	-	-	8	9	10	11	12	13	14	1 MB, IW, Nor. 3 F, Bd, Cam. 4 Dor, Do, He, Hun. 8 to 14 common.
„ „ var. nitida, *Reuss*	*	1	-	3	4	-	6	7	8	9	10	-	12	13	-	1 MB. 3 F. 4 Do, He. 6 Do. 7 Do, He. 8 Do, He. 9 He, Yo. 10 Dor, He, Nor. 12 W. 13 Nor, W, Dor.
„ exsculpta, *Reuss* -	-	-	-	-	-	-	-	-	-	-	10	11	12	13	14	passim.
Spiroplecta annectens, *J. & P.*	*	1	-	3	4	-	-	-	8	-	-	-	12	-	-	1 Cam, Dor. 3 Dor. 4 Dor. 8 Sus. 12 Bk.
„ anceps, *Reuss* -	*	1	-	3	4	-	-	-	-	-	-	-	-	13	-	1 MB, Dor. 3 Dor, IW. 4 Dor. 13 Nor.
„ biformis, *P. & J.*	*	-	-	-	-	-	-	-	-	9	10	-	12	-	-	9 Y. 10 WK, He. 12 Bk.
Spiroloculina asperula, *Karrer.*	*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	Yo.
„ alveoliformis,	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	Yo.
„ limbata. *d'Orb.*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ nitida, *d'Orb.*	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ papyracea, *Sh., B. & B.*	*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	F. Bd
„ tenuis, *Czjzek*	*	1	-	-	4	-	-	-	-	-	-	-	-	-	-	1 Cam. 4 Hun, Yo.
Textularia anceps, *Reuss* -	-	-	-	3	4	-	-	-	-	-	-	-	12	-	-	3 Bd. 4 Dor. 12 B.
„ agglutinans, *d'Orb.*	*	1	-	3	4	-	-	7	8	-	10	-	-	-	-	1 Cam. 3 F, Bd. 4. Dor, Do, He. 7 He. 8 He. 10 WK.
„ complanata, *Reuss*	*	1	-	3	-	-	-	-	-	-	-	-	-	-	-	1 Cam. 3 F.
„ conica, *d'Orb.* -	*	-	-	3	-	-	-	-	-	-	-	-	12	-	-	3 Bd. 12 Bk.
„ concava, *Karrer* -	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ decurrens, *Chap*	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	Bk.
„ fœda, *Reuss* -	*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1 Cam.
„ gramen, *d'Orb.* -	*	1	-	3	4	5	-	-	-	-	-	-	12	-	-	1 Cam. 3, 4, 5 common.
„ globulosa, *Ehr.* -	-	-	-	-	-	-	-	-	8	9	10	11	12	13	14	8 Sus, He. 9 Do. 10 WK. 11 Sus. 12 Bk. 13 Nor. 14 Tr.
„ „ var. striata, *Ehr.*	-	-	-	-	-	-	-	-	8	-	-	-	12	-	-	8 Sus. 12 Bk.
„ hybrida, *Chap.* -	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Cam.
„ minuta, *Berth.* -	*	1	-	3	4	-	6	-	-	-	-	-	-	-	-	1 Cam, Dor, IW. 3 Dor, F, Bd, Cam. 4 He. 7 Do, He.
„ prælonga, *Reuss*	*	1	-	3	4	-	-	-	-	-	10	-	-	-	-	1 Cam. 3 Dor, IW, F Bd. 4 Dor. 11 He.

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FORAMINIFERA—Cont.																
extularia quadrilatera, *Schw.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ sagittula, *Defr.*	*	1	–	–	4	–	–	–	–	9	10	–	12	–	14	1 Cam. 4 Dor. 9 Dor. 10 WK. 12 Bk. 14 Tr.
„ senata, *Chap.*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ trochus, *d'Orb.*	*	1	–	3	4	5	–	–	8	9	10	–	12	13	–	1, 3, 4, 5 common. 8 Sus. 9 Yo. 10 Kent. 12 Bk. 13 Nor.
„ turris, *d'Orb.*	*	1	–	3	4	5	6	7	8	9	10	11	12	13	–	Common in 1, 3, 4, 5, 6, 7 and 8. 9 Do, Yo, 10 WK, Do, He. 11 Sus. 12 W. 13 Nor.
„ sp. nov., or distorted.	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Cam. 4 Nor.
Triloculina (nr. tricarinata, *d'Orb.*)	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
Tritaxia foveolata, *Marsson*	–	–	–	–	–	–	–	–	8	–	–	–	–	13	–	8 Sus. 13 Nor.
„ minuta, *Marsson*	–	–	–	–	–	–	–	–	8	–	10	–	–	–	–	8 He. 10 Kent, He, Nor.
„ pyramidata, *Reuss*	*	1	–	3	4	–	–	–	8	–	–	–	–	–	–	Common in 1 and 3. 4 Dor, He. 8 Sus.
„ tricarinata, *Reuss*	*	1	–	3	4	–	6	7	8	9	–	11	12	13	–	1 MB, Cam, Dor, IW. 3 common. 4 Do, Dor, He. 6 He, Do. 7 He. 8 Sus. Do, He. 9 Yo. 11 Dor. 12 Bk. 13 Nor.
„ sp. nov.	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	12 NW.
Trochammina concava, *Chap.*	*	–	–	3	4	5	–	–	–	–	–	–	–	–	–	3 F, Hun. 4 Hun. 5 Yo.
„ sp. nov. 1	–	–	–	3	4	–	–	–	–	–	–	–	–	–	–	3 Yo. 4 Hun.
„ sp. nov. 2	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4 Yo.
Truncatulina akneriana, *d'Orb.*	–	–	–	–	4	–	6	–	–	–	–	–	–	–	–	4 He. 6 He.
„ culter ? *P.&J.*	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	He.
„ lobatula, *Defr.*	*	–	–	3	4	5	–	7	8	–	10	11	12	13	14	3 Bd. Cam. 4 Yo. 5 He. 6 He. 7 He. 8 Yo. 10 Nor. 11 Kent. 12 Bk. 13 Dor. 14 Tr.
„ (Marsson's figure)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	14 Tr.
„ refulgens, *Montf.*	*	–	–	–	–	–	–	–	–	–	–	11	–	–	–	Dor.
„ ungeriana, *d'Orb.*	–	1	–	–	4	5	6	–	8	9	10	11	12	13	14	1 IW. 4 Bd. 5 Do. 6 He. 8 Yo. 9 Dor. Common in 10, 11, 12. 13 Nor. 14 Nor.
„ variabilis, *d'Orb.*	*	–	–	–	–	–	–	–	–	–	10	–	12	–	–	10 Do. 12 Bk.
Uvigerina canariensis, *d'Orb.*	–	–	–	–	–	–	–	–	–	–	–	11	–	–	–	11 Bk.
Vaginulina æquivoca, *Reuss*	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3 Bd.
„ arguta, *Reuss*	*	1	–	3	4	–	–	–	–	–	–	–	–	–	–	1 Cam. 3 Bd. 4 He.
„ Biochei, *Berth.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ costulata, *Reuss*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
„ comitina, *Berth.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ legumen, *Linn.*	*	–	–	–	–	–	–	–	–	–	10	–	–	–	14	10 WK. 14 Tr.
„ striolata, *Reuss*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ recta, *Reuss*	*	1	–	3	4	5	–	7	8	–	–	–	–	–	–	1 Cam, Nor. 3 F, Bd, Cam. 4 Dor, Do. 5 Do. 7 Do. 8 Sus.
„ „ var. tenuistriata, *Chap.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ truncata, *Reuss.*	*	1	–	3	–	–	–	–	–	–	–	–	–	–	–	1 Cam, Nor. 3 F, Bd.

SPECIES.		Lower Chalk.					Mid'le Chalk.		Upper Chalk.							LOCALITIES AND REMARKS.
	Found in Selbornian. *	Chloritic Marl (Stauronema) 1	Devon Cenomanian, &c. 2	Chalk Zone of Am. varians. 3	Zone of Hol. subglobosus. 4	Zone of Act. plenus. 5	Zone of Rhynch. Cuvieri. 6	Zone of Terebratulina. 7	Zone of Hol. planus. 8	Z. of Mic. cortestudinarium. 9	Zone of Mic. coranguinum. 10	Zone of Marsupites. 11	Zone of Act. quadratus. 12	Zone of Bel. Mucronata. 13	Zone of Ostrea lunata. 14	
FORAMINIFERA—Cont.																
Vaginulina truncata, var. robusta, *B. & Ch.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam
„ „ var. eury-nota, *Reuss.*	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
Verneuilina proquinqua, *Brady.*	*	1	–	–	4	–	–	–	–	–	–	–	–	–	–	Dor.
„ parisiensis, *d'Orb.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1 Cam.
„ pygmea, *Egger*	*	1	–	–	–	–	–	–	–	–	–	–	12	–	–	1 Cam. 12 Bk.
„ spinulosa, *Reuss*	–	–	–	–	–	–	–	–	–	9	10	11	12	–	–	9 He. 10 He. 11 Dor, Kent. 12 Bk.
„ triquetra, *Montf.*	*	1	–	3	4	5	–	–	8	9	10	11	12	13	–	1 Cam. 3 F, Bd. 4 Do. 5 Do. 8 Yo. 9 Yo. Common in 10, 11, 12. 13 Nor.
„ variabilis, *Brady.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam, Dor,
Virgulina schreibersiana, *Czjzek*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
„ sub-squamosa, *Egger*	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	Bk.
webbina lævis, *Sollas*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ Sollasi, *Chap.*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ tuberculata, *Sollas*	*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	Cam.
„ sp.	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9 Ct.
RADIOLARIA.																
Acanthosphœra	–	–	–	–	–	–	6	–	8	–	–	–	–	–	–	6 Bd, He, 8 Sur.
Amphibrachium	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	6 Do, Bd, He.
Cenosphæra	–	–	–	–	–	–	6	–	8	–	–	–	–	–	–	6 Do, Bk, Bd, He, Cam, Yo. 8 Sur.
Coccodiscus	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Cyrtocalpis	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Dicolocapsa	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Dictyomitra	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Dorysphœra	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	6 Do, Sur, Bd, He.
Hagiastrum	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Lithapium	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Lithocampe	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Rhopalastrum	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Spongoplegma ?	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	6 Do, Bd, He.
Spongotripus	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Stauralastrum	–	–	–	–	–	–	6	–	8	–	–	–	–	–	–	6 He. 8 Sur.
Stylosphœra	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Theodiscus	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Trilonche	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Trigonactura	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Trigonocyclia	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.
Zygostephanus	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8 Sur.

APPENDIX II. —BIBLIOGRAPHY.

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B. *Maps.*

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1. S.E. Langdon Hill, Gravesend, Rayleigh, &c. 1868.
1. S.W. East London, Woolwich, Dartford, &c. 1868.
2. Sheerness, Shoeburyness, &c. 1868.
3. Canterbury, Ashford, Margate, Ramsgate, and Dover. 1868.
4. Country between Folkestone and Rye. 1863.
5. Hastings, Eastbourne, Hailsham, Lewes, Seaford, &c. 1864. New edition, 1893.
6. Bromley, Chatham, Maidstone, Tonbridge, &c. 1864, revised to 1889.
7. West of London, Windsor, Wendover, High Wycombe, &c. 1861, revised to 1872.
8. Croydon, Reigate, Dorking, Guildford, Farnham, &c. 1862, revised to 1868.
9. Brighton, Chichester, Horsham, Haslemere, &c. 1864. New edition, 1893.
10. Isle of Wight, 1856 (withdrawn). See New Series 330, &c., 1893.
11. Winchester, Southampton, Portsmouth, Petersfield, &c. 1858.
12. Newbury, Andover, Basingstoke, Alton, &c. 1860.
13. Oxford, Reading, Wantage, Lambourn, Thame, Henley, &c. 1860.
14. Marlborough, Amesbury, Westbury, Devizes, Warminster, &c. 1857, revised to 1859.
15. Salisbury, Blandford, Shaftesbury, Cranborne, &c. 1856.
16. Coast of Dorset from Hurst Castle to Lulworth. 1856.
17. Dorchester, Weymouth, and Bridport. 1850, revised to 1855.
18. Crewkerne, Beaminster, Sherborne, Yeovil, Cerne Abbas, and Wincanton. 1850, revised to 1875.
19. Bath, Frome, Wells, Mere, &c. 1845, revised to 1873.
21. Taunton, Tiverton, Honiton, Chard, &c.
22. Coast of Devon from Lyme Regis to Torbay, Exeter, &c.
34. Stroud, Cirencester, Calne, Swindon, and Marlborough Downs. 1857, revised to 1859.
46. N.E. Hitchin, Biggleswade, &c. 1869, revised to 1891.
46. S.E. Hatfield, Luton, Stevenage, &c. 1867.
46. N.W. Newport Pagnell, Winslow, Woburn, &c. 1864.
46. S.W. Aylesbury, Tring, Dunstable, &c. 1865.
47. Hertford, Bishopstortford, Sudbury, Braintree, &c. 1881.
50. S.W. Lavenham, Stowmarket, &c. 1881.
50. N.W. Ixworth, Botesdale, Diss, and Eye. 1882.
50. N.E. Harleston, Halesworth, &c. 1883.
51. S.W. Country round Cambridge. 1881.
51. N.W. Ely, St. Ives, &c. 1882.
51. S.E. Newmarket, Bury St. Edmunds, &c. 1882.
51. N.E. Mildenhall, Culford, and Thetford. 1883.
66. S.W. Attleborough, Watton, and Wymondham, 1884.
66. N.W. East Dereham, Litcham, &c. 1885.
68. E. Norfolk coast by Sherringham, Cromer, Mundesley, &c. 1883
68. S.W. Holt, Fakenham, Wells, &c. 1885.
68. N.W. Norfolk coast from Weybourn to Wells, 1883.
69. The Wash, Boston, Hunstanton, Docking, &c. 1886.
83. Lincoln, Market Rasen, Horncastle, &c. 1886.
84. Alford, Spilsby, and Louth and East Coast. 1884.
86. Caistor, Hull, and Humber Estuary. 1888.
94. S.W. Beverley, Market Weighton, &c. 1884.
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267. Newbury. 1898.
268. Reading. 1898.
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283. Andover. 1898.
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299. Winchester. 1896.
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329. Bournemouth. 1895.
330. Parts of New Forest and N.W. of Isle of Wight. 1893.
331. Portsmouth and N.E. part of Isle of Wight. 1893.
334. Newhaven and Eastbourne. 1893.
330. 331, 344, 345. Isle of Wight with mainland. Second edition, 1893.
339. Newton Abbot. 1902.
341. Dorset coast, Langton Herring, 1895.
342. Portland, Weymouth, Lulworth. 1896.
343. Swanage and Corfe. 1895.

C.—Horizontal Sections, on a scale of 6 inches to a mile.

* Those marked thus have brief explanations.

16. No. 1. From Mere, in Wilts, to Vobster, in Somerset. 1845. Revised to 1871.
19. From Knighton Heath (Dorset) to near Honiton (Devon). 1851.
20. From Portland Bill to near Castle Cary (Somerset). 1852.
21. From the sea at Golden Cap (Dorset) to the River Brue, south of Glastonbury Tor (Somerset). 1852, revised to 1873.
22. No. 2. From the Coast near Lulworth to Cadbury Castle (Somerset).
56. Sections through South Dorset from the coast. 1859.
*59. From Marlborough Downs across the Cotteswolds to the River Avon. 1860.
*71. From Nettlebed Hill (Oxon) to Burton Dassett Hills (Warwick). 1867.
*72. No. 2. From Lambourn Downs (Berkshire) to Kencott (Gloucestershire). 1867.
73. From Selsea Bill (Sussex) to Chobham Ridges (Surrey). 1868.
74. From Chobham Ridges (Surrey) to Bishopstone (Bucks). 1868.
75. From near Worthing (Sussex) to Hampton (Middlesex). 1867.
76. From near Brighton to the North Downs near Merstham. 1867.
77. From west of Newhaven Harbour (Sussex) to Knole Park and the North Downs of Kent. 1867.
78. From near Beachy Head to near Boxley, N.E. of Maidstone. 1867.
79. Across the London Basin, from Beddington (Surrey) through London to near Hemel Hempstead (Herts). 1868.
80. From near Gosport (Hampshire) through Berkshire, Oxfordshire, and Warwickshire to Tamworth in Staffordshire. 1870.
81. From near Gosport (Hampshire) to White Hill near Kingsclere, and from White Hill to near Pinsley Wood in Oxfordshire. 1870.
84. From Boxley (Kent) to the River Chelmer (Essex). 1871.
120. From near Farningham (Kent) to Widford (Essex). 1871.
121. Across Hertfordshire and Bedfordshire to near Kimbolton, 1878.

125. From near Dunstable (Beds) by Woburn to Mears Ashby. 1881.
126. From the river Chelmer (Essex) to Cambridge and Madingley. 1882.
*127. The Norfolk Cliffs from Happisburgh to Weybourn. 1882.
*139. Section along the Western Escarpment of the Yorkshire Wolds; illustrating the overstep of the Cretaceous Rocks. 1884.

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N.B.—Of works published before 1800, only a few of the more important publications are mentioned. Papers on Water supply are not included.

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1789.

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1801.

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1804–1811.

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1808.

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1812–1815.

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PLATE IX.

FIG. 1.

CHALK ROCK, MEDMENHAM, BUCKS.

a. a. Echinoid fragments present in nearly every specimen of the chalk at this horizon ; *b.* a sponge spicule ; *c.* Cristellaria ; *d.* Pulvinulina ; *e.* Globigerina ; *f.* grains of glauconite ; *g.g.g.g.* minute tubular holes, probably casts of minute sponge spicules present in most specimens of Chalk Rock.

FIG. 2.

CHALK ROCK, HITCHIN, HERTS, SHOWING A PORTION OF A PHOSPHATIC NODULE.

a. the nodule ; *b.* the matrix ; *c.c.* Echinoid fragments ; *d.* Globigerina ; *e.e.e.e.e.* minute tubular holes ; *f.* grain of glauconite.

Note.—This Plate follows on from Plate VIII. in Vol. II. of this Memoir.

Plate IX.

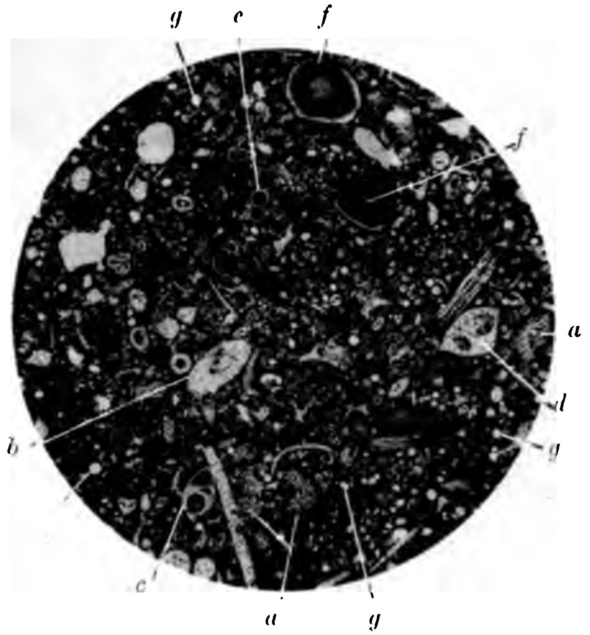

Fig. 1. Chalk Rock. Medmenham.
× 22 diam.

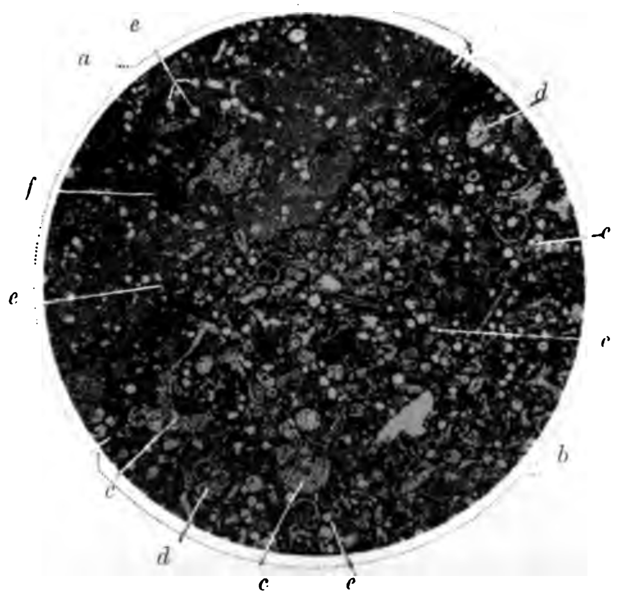

Fig. 2. Chalk Rock, shewing portion of nodule.
Hitchin.
× 22 diam.

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